SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXIX JUNE, 1939 WHOLE NO. 341

SPEAKERS FOR THE 1939 CONVENTION

The President of the Association, Marie S. Wilcox, outlined the program for the Annual Convention in the May issue of the Journal. This meeting will take place in the Morrison Hotel in the City of Chicago on December 1 and 2, 1939. Further information is now available. The section Officers and Directors met on May 6 in Chicago to continue work on the program. Dr. E. R. Hedrick, Vice President and Provost of the University of California at Los Angeles and a recognized authority in the field of mathematics has promised to speak at both the general and mathematics sessions unless something unforeseen prevents. Dr. B. J. Luyet, St. Louis University School of Medicine, will address the general session on the subject of Life and Death. Dr. George Skewes, State Teachers College at Mayville, N. Dakota, will discuss The Scientific Method. Other speakers on the various programs will be Dr. Selby Skinner of the University of Chicago, who will discuss The Physical Science Sequence; Mr. W. O. Smith of South High School of Cleveland, who will talk on Social Arithmetic in the 10th Grade; Dr. Frank B. Kirby, Abbot Laboratories, who will talk on Vitamins; Dr. Helen Strong of the United States Department of Agriculture, who will discuss Soil Conservation; Dr. Ivey of the Department of Philosophy of Northwestern University, who will discuss Hormones and Their Effect on Learning; J. W. Combs of DesMoines, who will talk on the Flying Telephone As Used in Aeronautics; Miss Winifred Gilbert of Iowa State Teachers College, who will discuss Teaching and Testing Skills in General Science; Miss Katherine Pfiefer of St. Louis, who will discuss Club Work and Extra-

Curricular Activities; Glady Forler of Shorewood, Wisconsin; Gerald Craig of Columbia University, who will talk on Does Elementary Science Teach Children to Think?; Rose Lammel of the University Training School at Ohio State University, who will discuss How Correlate Science With Other Subjects?; and Mr. Dean Stroud of Amos Hiatt Junior High School of Des Moines, Iowa, who will discuss Science for Leisure Time.

INCORPORATED NOT FOR PROFIT?

Who are the stockholders; who makes the profit from this organization; or, in the vernacular of the street, whose racket is the Central Association of Science and Mathematics Teachers? The above question with its implications was asked by one of the members at the 1938 convention held in Chicago. It seems quite logical for one not acquainted with the history of the Association to wonder whether a small group of individuals is benefiting from its incorporation.

A teacher becomes a member of the Association by paying the annual fee of $2.50 which entitles such member to nine issues of the official Journal, SCHOOL SCIENCE AND MATHEMATICS, and to all privileges of membership in the Association. A teacher who subscribes to SCHOOL SCIENCE AND MATHEMATICS at the annual rate of $2.50 becomes a member of the Central Association of Science and Mathematics Teachers simply by indicating his wish to the Treasurer, Mr. W. F. Roecker, of Milwaukee.

In petitioning the State of Illinois for a charter, the following purposes of the Association were set forth:

To facilitate the interchange of ideas and information of interest to teachers of science and mathematics.
To encourage personal contacts and acquaintanceships at meetings held under the auspices of the Association.
To establish professional standards.
To stimulate investigation and research work.
To collect, compile, publish, and disseminate educational articles, professional contributions, and statistics of interest to the public and to teachers of science and mathematics.
To facilitate the purchase, management, and publication of the Journal, SCHOOL SCIENCE AND MATHEMATICS.

In studying the history of the Central Association of Science and Mathematics Teachers from its inception, one is profoundly impressed by the sacrifice and effort on the part of its members at every period of its life. The Journal, with its total circulation of approximately 3,000, has been fully paid for

and is an asset belonging to the membership. The management of the affairs of the Association is delegated by the members to a Board of Directors elected by the membership.

The Association has never paid a cash dividend nor has it ever become the source of profit to any individual or group. The Directors attend all meetings and make contribution of time and talent at no cost to the membership. They carefully delegate responsibility to individuals and firms and delegate payment in proportion to service rendered. Each member is entitled to vote at the annual business meeting.

The title of the article is in the form of a question: *Incorporated Not For Profit?* As pointed out, cash dividends are not paid to any member. The Association makes its contribution to the membership in proportion to the interest and effort of the members and in proportion to the size of the membership. We who are now members benefit through participation in an activity that has and will continue to influence teaching of science and mathematics.

Plan to attend the December meeting. Encourage other teachers to join the Association. Write to the President and criticize constructively; make a contribution to the magazine; actively engage in participation at meetings; and send to section chairmen any suggestions you have for a program improvement. Don't sit on the sidelines; get into the activity of your Association. You will become a better teacher and the world will become richer.

HAROLD H. METCALF, *Secretary*

METEORITE HUNT

Soviet geophysicists will make an effort this summer to locate the pieces of the giant meteorite of 1908, that devastated many thousands of acres of timber when it plunged into Siberian earth and exploded, near the Podkamennaya Tunguska River.

During the summer of 1938 the first photographic air mapping of the region was carried out. The "blowdowns" of timber caused by the explosion indicate that the enormous mass split into several large fragments before it fell. It is hoped that geomagnetic instruments will aid in locating their exact positions.

There is but one temple in the universe and that is the body of man.

WHAT IS UNFAMILIAR ABOUT THE FAMILIAR TIN CAN*

L. G. Weimer
American Can Company, Research Department, Maywood, Ill.

How often the commonplace fails to arrest our attention! We are all somewhat prone to accept the conveniences of daily life without exhibiting any curiosity as to the circumstances surrounding their origin and their refinement to present day standards. In such a category we may place the automobile, the airliner, the radio and the modernized version of one of life's essentials—Canned Foods.

Methods of food preservation such as drying, salting and smoking, which date back to antiquity, were the only devices known to 18th century civilization to prevent the decomposition of foodstuffs. Such procedures were limited in their application and often poorly executed with the result that malnutrition among the armies as well as the civilian population and scurvy in the navies were prevalent in the countries of the Old World. It was the French, however, who first sought to alleviate these deplorable conditions and in 1795 that Government offered a prize of 12,000 francs for the discovery of an improved method of preserving food.

Nicholas Appert, a Parisian confectioner, began experimenting with methods of food preservation and by 1809 had succeeded in preserving fruits, vegetables and meats. Appert's "Art of Preserving" which won the award consisted of packing food in specially designed widemouth glass bottles—since they were "most impermeable to air," heating them to the boiling point of water followed by hermetically sealing the containers with specially fabricated corks. Rigorous tests to disarm the skeptical demonstrated that Appert's preserved foods withstood shipment to equatorial climates and were edible after long storage periods.

Although Appert could not explain the underlying principles of his procedure, we cannot fail to appreciate the magnitude of his achievement when we consider the dearth of scientific knowledge of the early 19th century. Chemistry was emerging

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* Address before Chemistry Section of Central Association of Science and Mathematics Teachers, LaSalle Hotel, Chicago, Illinois. November 25, 1938.

from the mysticism of alchemy and the science of bacteriology was unknown. Appert surmounted these obstacles through sheer ability as a logical observer and a methodical worker—truly the qualifications of a scientist and one worthy of being hailed as "The Father of the Canning Industry."

After Appert's invention, canning or preserving soon developed into an industry in France. Throughout this period the technique of canning had been improved by countless experiments conducted by Appert based solely on trial and error methods. It was not until 1860 that Louis Pasteur offered the scientific explanation of Appert's art as a result of his research with micro-life and the part they play in fermentation and food spoilage. Thus, the scientific cornerstone of the canning industry was laid. However, the industry was destined to advance only as rapidly as new scientific facts were established.

Early canners were handicapped, however, by the fragile and bulky glass containers which were difficult to seal. In searching for a more suitable container, Appert experimented with round, oval and rectangular shaped tin cans which were an adaptation of the canister then in use for packaging tea. Due to the poor quality and ductility of the tin plate of the period, Appert substituted wrought-iron casseroles plated with tin. The selection of tin as the most suitable metal to be in intimate contact with the food was not mere chance since, in the search for a likely metal or alloy, tin had been found to be harmless to health.

In England, which was rapidly becoming canned food conscious, Peter Durand, a worker in tin, developed soldered handmade cans from Welch tin plate which were far superior to the French product. Progress was slow because of the costly production of these containers as a skilled workman could only produce about 600 cans per day. Spoilage losses due to the use of imperfectly soldered containers and rule-of-thumb sterilizing methods also began to sap the financial strength of the industry. In seeking a solution to these problems the first "sanitary can" was developed in Europe. The newer type can lent itself to semi-mechanical production since solder was used only at the side seam and the ends, provided with heavy rubber gaskets, were mechanically crimped onto the can bodies. Progress was also being made in sterilizing canned foods with the introduction of the calcium chloride bath which was a direct result of Sir Humphrey Davy's earlier discovery of the higher boiling points of such solutions.

The early history of canning in America was beset with hazards and obstacles much the same as was the struggling industry of Europe. The first American canner, according to available records, was William Underwood of Boston, who began preserving marine foods and fruits as early as 1819. The progress of the canning industry in this country was handicapped by the lack of an efficient low-priced container and the uncertainty of existing canning procedures. During the Civil War the demand for canned foods became widespread and proved an impetus for increased activity. American ingenuity and mechanical skill met the challenge and soon produced efficient can making machinery to replace hand labor, thereby increasing the output of cans from 600 a day to over 100 a minute. With the invention of the steam retort by A. K. Shriver in 1872, which was an adaptation of the laboratory autoclave, the canning industry gained one of its most efficient tools up to the present time.

At the turn of the century the industry emerged into the modern era. The passing of protective tariffs fostered the manufacture of domestic tin plate. The increased demand for containers by the canning industry brought about the establishment of still another industry—that of can manufacturing. Although mechanical skill was improved, the scientific facts of food preservation or food spoilage were still unknown. Investigations were instituted by universities and Federal Agencies and finally Research laboratories grew up within the industry to study these problems. Few realize that it has been only within the last three decades that the untiring efforts of chemists, bacteriologists and physicists have made the canning industry an applied science as well as an art.

In viewing the canning industry of today, we should consider first the basic material from which the tin can is fabricated. Tin plate consists of about 98.5% steel and 1.5% tin. The steel used for tin plate, containing over 99% iron, is cast into ingots and subsequently rolled into bars. In the tin mill, the steel bars are subjected to heating and rolling procedures to form sheets of about 1/16 of an inch in thickness. Following a pickling operation in hot acid to remove the iron oxide scale, the steel sheets are either hot or cold rolled to the proper gauge and the stock submitted to an annealing process. The annealed base plate sheets are cut to size and passed through a bath of pure molten tin. The tin pot is so constructed that the base plate first passes

through a fluxing solution into the molten tin and upward through a series of rollers which distribute and govern the thickness of the tin coating. The tin plate emerges from the pot through a layer of palm oil which prevents oxidation of both the molten tin as well as the tin coated sheets. The palm oil coated sheets of tin plate next pass through a cleaning machine where the plate is polished and excess palm oil removed by wheat or rye bran. Following a rigid inspection of each sheet of tin plate it is ready for shipment to the can manufacturer.

The problem of tin plate corrosion when used for acid products such as fruits, pickles and sauerkraut confronted the industry for a number of years. Acid foods were found to attack the base metal of the container with such rapidity that the merchantable life of this class of canned foods was limited to six months or less. Loss of merchantability was evidenced by the evolution of hydrogen causing an internal pressure sufficient to bulge the ends of the can. In more advanced stages of this corrosion, small areas of the containers "pinholed" as a result of the acid consuming the base metal.

The explanation of the complex mechanism of corrosion in canned foods has led to some disagreement. It is generally accepted, however, that the relative differential in solution potentials between the tin coating and the steel base of the can, under the conditions existing in a hermetically sealed tin can, is the causative factor. From the position of iron in the electrochemical series, it may be assumed that iron is less noble than tin. Notwithstanding, in considering the tin-iron couple existing in the tin container, data collected by research laboratories affiliated with the canning industry have led to the conclusion that tin is anodic to the iron of the can. If this was not the case, the tin can would not be a suitable container for most canned fruits.

Fruit acids in themselves are relatively weak acids and have little effect in corroding tin. In the plain can, the combined action of these acids, with the anthocyans of pigmented fruit which are powerful hydrogen as well as metal acceptors together with any oxygen, both occluded and in solution in the canned food, act as depolarizers and have considerable corrosive action on the tin. The anthocyans acting as metal acceptors break down the salts of the fruit acids with the metals of the can, thus releasing the acids for further attack upon the can. In the enamel-lined can, the relatively greater area of cathodic

iron exposed at regions where the enamel film and tin coating may have become fractured during fabrication processes also effects a corrosive action on the tin anode. As the reaction progresses and tin passes into solution, the iron loses the protective effect of anodic tin and is able to set up local couples which result in hydrogen formation and finally perforation of the steel base occurs.

Tin has an inhibiting effect on the iron corrosion apart from its being less noble than iron in the hermetically sealed can. Tin in solution, even to the extent of a few parts per million, has been demonstrated to have enormously increased the over-voltage of iron and the protective action of the soluble tin is due to this phenomenon. As tin is taken out of solution by the seeds of fruits and berries and as tin proteates by the protein of fruits and vegetables, the iron loses its over-voltage and the base plate corrodes.

Years of research in studying the sub-aqueous corrosion of tin plate led to the discovery that the presence of phosphorus and silicon, had considerable influence on the corrosion resistance of tin plate. The development of the cold reduction process of tin plate manufacture made it possible to reduce the phosphorus and silicon components of the steel to limits which were impractical by the former hot reduction method. Cold reduced tin plate, because of its more uniform crystalline structure and low metalloid content possesses better resistance to corrosion, as well as improved drawing properties. More recently methods have been developed whereby the comparative corrosion resistant properties of tin plates can be determined by an accelerated chemical test in less than 48 hours, thus making it possible to supply the canner of corrosive products with a tin container of increased service life.

There has been considerable improvement as well in the manufacture of the cans. The hand-cut, hand-formed, hand-soldered cans of a century ago have been replaced by today's modern "sanitary" can. The transition was a gradual one, however, and was marked by improvement in forming and soldering and the displacement of hand-cut ends by mechanical stamping of the can ends. Former lap seam inside soldered bodies were replaced by the lock seam can which was automatically soldered on the outside over a solder roll. About forty years ago the first sanitary can appeared in this country and differed from its predecessors by virtue of the fact that the die stamped can

ends were seamed in place with a gas-tight rubber gasket instead of being soldered to the can body. Fully automatic machinery fostered by mass production now produce sanitary cans at the astounding rate of 300 and more a minute. So exacting are the tolerances and so rigid is the inspection to which the cans are submitted that can manufacturers guarantee 998 out of 1,000 cans against manufacturing defects.

Bleaching of the pigments of red and blue fruits due to the reducing effect of tin and the formation of black ferrous sulphide with sulphur-bearing products such as corn, peas, meats and marine products when packed in plain tin containers proved a sales disadvantage for canned foods. It was not uncommon for these foods to be brown, purple or black as a result of their chemical reaction with the metal of the container.

Early enamels which were developed were subject to hydrolysis and turned almost white a short time after canning. Due to a lack of knowledge on the subject, many of the first enamels that were tried imparted objectionable flavors to the canned food. Finally, in 1926, Roger H. Lueck, working in the Research Laboratories of the American Can Company, devised and perfected an inert enamel coating for corn and other sulphur-bearing vegetables which would prevent the formation of ferrous sulphide or "corn black." This coating, which was applied and baked to the flat tin plate before it was fabricated into cans, became known as "Corn-Enamel" or C-enamel. Later another enamel was developed for pigmented fruits to prevent color bleaching and is now known as Fruit or Sanitary enamel. The behavior of various foods in the can is too specific to enable one can enamel to serve equally well for all foods. Citrus fruits require still a different enamel while the enamel systems used for beer and wine are far different and more highly complex than those required for the more common canned foods.

Today, can enameling has become highly specialized. At one time it was thought that the baking of enamels was chiefly an oxidation process. Later research has demonstrated, however, that the resistance of enamels to various foods is as much a function of polymerization as oxidation. As a matter of fact, with the newer synthetic condensation resins which are incorporated in can enamels, oxidation plays no part in the operation of baking them on the tin plate. The industry through scientific research knows something of the complicated problems of enamel adhesion to tin plate and is no longer solely

dependent upon empirical knowledge. In the future as further investigational work progresses, enamels will be produced that can be made almost as much a part of the tin plate as the tin itself.

Contemporary with the advances being made in can manufacture, enamel coating systems and the metallurgy of tin plate, the fundamentals of canning technique were being explored and placed on a scientific basis. To understand this phase of canning research, we must refer again to the underlying principle of canning established by Appert. Canning is the sterilization of food through the heat destruction of spoilage organisms and the subsequent protection of the sterilized canned food by hermetic closure from recontamination. From the canners' viewpoint, it was necessary to identify the microorganisms causing spoilage and then to determine the conditions necessary for their growth. In working out the bacteriology of canned foods, the industry is indebted largely to Prescott and Underwood of the Massachusetts Institute of Technology who first traced the spoilage of certain lots of canned cream style corn to imperfect sterilization, as well as to Russell of Wisconsin and Barlow of the University of Illinois, the latter having demonstrated that thermophilic or "heat-loving" bacteria capable of growth at temperatures as high as 150°–160°F. were often the cause of canned food spoilage. Generally speaking, canned food spoilage is of two types; that in which gas is produced by the natural metabolism of the causitive organism in sufficient quantities to bulge or burst the cans, or the more insidious type known as "flat sour" spoilage, wherein excessive souring of the food occurs and little, if any, gas is produced. Bacteriologists associated with the canning industry, with their present knowledge of the morphology of spore-formers, thermophiles, aerobes and anaerobes, can trace the various types of spoilage to imperfect sterilization, improper cooling or failure of the hermetic closure.

Bacteriologists investigating canned food spoilage have determined the thermal death times of the various food spoilage bacteria or in other words, the time required to destroy them at a given temperature in various foods. Chemists have determined the pH or hydrogen-ion concentration of the large number of canned foods since it was found to have a definite bearing on the bacterial flora which may be expected in various classes of canned foods. Supplementing the efforts of the bacteriologist

and the chemist, the physicist and mathematician have developed precision methods for determining the rate at which heat is transferred by conduction or convection to the center of the can during the processing or sterilization procedure. The rate of heat transfer is determined by means of a copper-constantan thermocouple and the effects of density of the product, size and shape of the container, and the relative position of the can during the process must be taken into consideration. By combining the heat penetration curve with the thermal death time curve of the most heat resistant bacteria known to exist in the food product, a series of differential equations have been evolved to permit the mathematical calculation of the required length of process necessary for a specific canned food at a given temperature. Based on this research work, the National Canners Association Laboratory has published "safe" processes for all of the commonly packed non-acid foods. This handbook of processes or sterilizing schedules is used by the canner and providing that the bacterial population of the raw material or the canning equipment does not exceed the normal load, freedom from spoilage is practically assured.

It is a mistaken idea that canned foods are packed from surplus crops. The discovery that many garden varieties of fruits and vegetables were not well suited for canning purposes has led horticulturalists connected with both State and Federal experiment stations to develop special strains for the canner. The growing and harvesting of canning crops is under the careful supervision of the canner whose aim is to select the particular fruit or vegetable at its peak of perfection and in an hour or two prepare it for the can.

Modern canning technique has become so highly specialized that neither the nutritional value of the food is lost nor the appearance and full flavor greatly changed in the canned product. In the actual canning procedure itself, the raw materials are given a thorough water cleansing, usually by washing under high pressure cold water sprays. Undesirable raw material is removed by sorting, trimming, peeling, and coring as occasion demands. With some products, these operations are performed automatically. With certain products, such as peas, and green beans, the next procedure is blanching or scalding by immersion in hot water. This process serves not only to further clean the product, but also softens the tissues and expels the interstitial air. Sometimes it is necessary to precook the product before it

is filled into the cans, or it may only be necessary to fill it into the cans and add hot water, salt brine or syrup. The filled cans may then be subjected to heating either in atmospheric steam or hot water in order to expel the air from the can, thus incorporating the principle which Appert discovered from producing a vacuum in the container by thermal means. Recently, it has been found that some products lend themselves to vacuum packing, which is accomplished by mechanically drawing the air from the cans filled with a dry or semi-dry product. Both the thermal and mechanical methods for producing a vacuum serve to exclude air from the container. Only then is the top end hermetically sealed on the properly exhausted and filled container. Finally, the sealed cans are heat processed in steam at temperatures ranging from 240° to 250°F. to destroy the food spoilage microorganisms after which the cans are cooled in water or are allowed to thoroughly air cool.

In the past the scientific investigations carried on within the industry have been largely devoted to the problems attendant upon understerilization, corrosion and discoloration. Generally speaking, these problems have been solved. But what of the future? It is not unreasonable to predict the perfection of procedures which will preserve the original color, flavor and uniformity of the raw product to a greater degree than is possible at the present time. The use of "flash sterilization" methods wherein commercial sterility is accomplished in a few seconds at temperatures in the range of 300°F. will probably supplant present sterilizing procedures which differ only slightly from those introduced by Appert.

The chemistry of chlorophyll, the organic pigment of green vegetables, is undergoing careful study and there is a reasonable possibility that its preservation can be effected through pretreatment of the food and pH control in the can. Physical and chemical methods of quality grading of the raw product before canning will receive consideration and outmode present visual inspection methods now subject to errors of human judgment in order to bring about greater uniformity of grades in the canned product. Present research trends indicate that tin may some day be replaced by other metallic coatings, or even by a coating of organic nature, which properly formulated, will be less effected by contact with food than a metallic coating. If present research programs can be taken as an indication, the

developments of the next decade will lead to even a greater popularity of canned foods.

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NATURE GUIDE SCHOOL

"Cap'n Bill" Vinal will open the Massachusetts State College Nature Guide School at Pine Tree Camp, Plymouth, Massachusetts, June 17. This is the date of the Pre-camp School for Nature Leaders. The regular six weeks' camp opens on July 5 and closes August 11. A 1939 Pine Tree Camp booklet may be obtained from Miss Ruth Stevens, National Girl Scout Office, 87 Beacon Street, Boston, Massachusetts.

FIRST AID IN THE SCHOOL

John P. Wessel
Wright City Junior College, Chicago, Illinois

Many of the smaller colleges are without a health clinic. Their budgets will not allow it. Two years ago a committee from the pre-medic club presented a request that a health clinic be established at Wright College. Although the request could not be granted, the administration recognized the value of having some sort of health service available for the students. It was suggested that a first-aid station be organized.

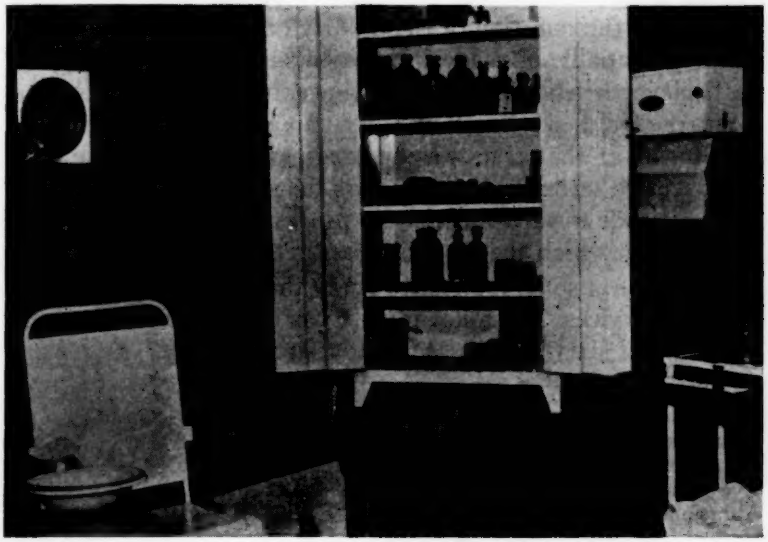
Some of the members of the club, together with the faculty sponsor, proceeded to organize two first-aid stations, one for the men and one for the women. These stations have now been in operation two years. The purpose of this article is to describe the nature of these first-aid stations.

The zoology instructor, who is also the faculty sponsor of the pre-medic club, is in charge of the first-aid stations, although he rarely renders first-aid service. The actual work is carried on by the students. There is a student *director of first-aid* in charge of each station. The qualifications necessary to hold this position are successful completion of an American Red Cross first-aid course, and at least one year of experience. The director of first aid is appointed by the faculty sponsor. During each class hour there are two attendants present in each station. The person in charge is called the *senior attendant;* the other, the *junior attendant.* The qualifications necessary to become a senior attendant is the successful completion of an American Red Cross first-aid course or one year of experience in our first-aid station. The only qualification for junior attendant is membership in the pre-medic club. After the junior attendant has successfully completed one year, he automatically becomes a senior attendant.

Each director of first aid conducts a class the members of which are the attendants. In their weekly meeting the textbook used is the American Red Cross First-Aid Manual.

A record of all services is kept, the main purpose of which is to protect the college should any charges be made against the first-aid station. During the two years that these stations have been operating, however, the records have not been called into question. Only such services as are listed in the American Red Cross First-Aid Manual are rendered. No internal treatments

are given. Should the immediate services of a physician be needed, either the student is taken to a neighborhood physician, or a physician is called to the college. In each station there is posted a list of physicians and the time each is available. At least one physician is available every hour of the school day. As a result of conferences these physicians both understand and approve it. Furthermore, through their cooperation we receive the recognition of members of the American Medical Association.



First Aid Room

A portion of the zoology laboratory, which at Wright College is the length of two and one-half ordinary class rooms, has been partitioned off to form two small rooms, each about ten by fifteen feet. One room is for the men and the other for the women. Each is equipped with a cot, a pillow, two blankets, an infra red lamp, a first-aid service chair with head rest, an arm rest, a leg rest and basin attachments, an adjustable service floor lamp, a cabinet for supplies, an eye glass, an ear syringe, a pipette, a scissors, a forceps, a waste container with an automatic foot control, a hot water container with an automatic thermostat, a service stool, a towel rack, and table and chair. This equipment was purchased with student monies obtained from student activities such as dances and plays.

The supplies include cotton, bandages of various sizes, muslin, tourniquets, aseptic emergency bandages for minor cuts, aseptic steripads, waterproof adhesive plaster of various sizes, splints, aseptic wood applicators, iodine, tannic acid with chlorbutanol solution, boric acid, lime water, hydrogen peroxide, ether, 70% alcohol, aspirin, petroleum jelly, unguentine, oil of cloves, spirits of ammonia, and antiseptic liquid soap.

It is quite obvious that these first-aid stations belong in the category of extra-curricular activities, and that they constitute a student project maintained by the pre-medic club. This raises the question of the quality of the services that students are capable of rendering. To be sure it is not always the best. Nevertheless, during the spring semester of 1938 the stations rendered six hundred sixty-two services. The student enrollment at that time was approximately fourteen hundred. Such service seems to indicate that the students have a wholesome attitude toward the first-aid program, and that they sense the spirit in which these services are rendered.

It may be of some interest to study the frequency of different types of services. The following list has been gathered from the six hundred sixty-two cases already cited.

Hand injuries (cuts)	172
Headaches	126
Sprains and strains	96
Miscellaneous minor injuries (cuts)	82
Eye injuries	40
Abrasions	37
Burns	35
Blisters	30
Toothaches	19
Earaches	11
Foreign bodies	11
Fainting	3
Cases requiring physician	3

The hand injuries, miscellaneous minor injuries, eye injuries, and burns total three hundred twenty-nine cases. Many of these have their origin in the chemistry laboratories. Many of the ninety-six sprains and strains occur in the gymnasium and on the athletic field. Besides serving the general student body, the stations seem to be giving a rather important service to the departments of chemistry and physical education.

In concluding may it be said that these first-aid stations have given fairly good service at a cost any school can well afford. It has also proved to be an important wedge in opening up a

relationship of mutual benefits between the school and its neighborhood physicians. The educational values of this program should not be overlooked. It helps to develop leadership, a cooperative spirit, and an appreciation of the value of first-aid technique.

AN EASILY CONSTRUCTED MODEL OF THE EARTH

WILLIAM A. PORTER
Chisholm, Minnesota

Schools which do not have a globe and an illuminator, and wish to demonstrate the relation of the tip of the earth to the seasonal change in our climate, can overcome the difficulty by constructing the device shown in Figure 1. A stick 28 inches

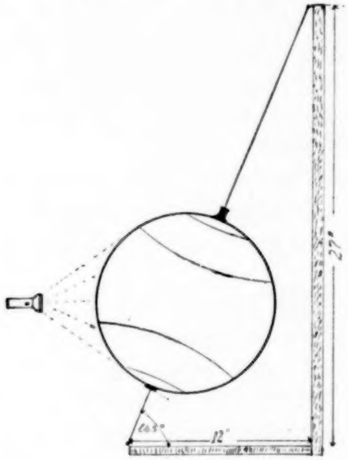


FIG. 1

long is nailed to a base 8×12 inches. A toy balloon, that may be inflated to 10 or 12 inches in diameter, or a basketball is supported as shown in the illustration. The supporting string, which represents the earth's axis of rotation, makes about a $23\frac{1}{2}°$ angle with the perpendicular if the dimensions given are followed. The basketball may be supported by suction cups.

Rough sketches of the continents may be painted on the balloon, and the parallels shown in contrasting color. The construction of this apparatus is an excellent project for fifth or sixth grade science classes, and is a fine teaching device in the lower grades.

PRIMARY CHILDREN EXPERIENCE SCIENCE[1]

GLADYS FORLER, MERIDEL UNDERWOOD,
AND MARJORIE PRATT
Shorewood Public Schools, Shorewood, Wisconsin

EDITOR'S NOTE—This article is the last of a series of four contributed by different writers and designed to be of practical interest to teachers of elementary science. The authors of this article have developed an excellent science program for the elementary grades which is fully described in *Science Experiences*, a publication of the Shorewood Public Schools.

The first article of this series appeared in the March issue. It described the construction of aquariums, vivariums, and other classroom equipment. The second article appeared in the April issue and outlined suggestions for the care and handling of pets. The third article described activities in the upper elementary grades and was published in May. The four articles together make a useful reference book for elementary science teachers.—D. W. R.

The simple experience of raising a small garter snake created problems which challenged the thinking of one group of first graders. Reading situations were made purposeful, occasions arose for ideas to be expressed in a written form, and a new vocabulary was acquired.

A science program in the primary grades is made up of one challenging experience after another because with each experience the child is finding out something new about his environment.

There is no need for any teacher of children to evade the teaching of science, for elementary science is a gradual revelation of the truths of one's environment through observation and experiences in which the teacher is a willing learner with the children. The essential requirement in making science function in the primary grades is an understanding teacher who is as interested in "finding out" as are the children she teaches. Child and teacher are in a very firm partnership when they are both searching to "find out."

A. DEVELOPING A STIMULATING ENVIRONMENT IN THE CLASSROOM

The bulletin board. One bulletin board should be ever ready to receive pictures from the newspapers, drawings or poems.

[1] This article has been condensed from an extensive and comprehensive account of science activities in the primary grades including illustrations and samples of tests now being prepared. Copies of the unabridged bulletin may be secured by addressing the Curriculum Office. Shorewood Public Schools, 2100 East Capitol Drive, Milwaukee, Wisconsin.

An ever-ready, ever-changing bulletin board, which bears daily attention, is always stimulating.

Another bulletin board is needed by children to display their contributions to the problem being studied. In a third grade room where children were studying simple machines, the exhibit board had hanging on it a can opener, an egg beater, a scissors, a knife, a file, a spoon, a screw driver, a nut cracker, a hammer, a wagon wheel, and a spoke from a wheel. Every day some new machine was contributed to the bulletin bôard exhibit.

The bulletin board can be made most revealing if labels explaining its various exhibits are worded to throw out a challenge to the observer.

The exhibit table. A table should be available where the children can exhibit articles which relate to the problem. After Christmas, a first grade class exhibited toys—a train, a steam shovel, a cart, a set of tools; all were available for children to inspect. Signs above the exhibit table worked out by the teacher and the children explained the displays.

Cages for animals. A cage for the larger animals, which may be brought into the room for a short time, is a source of stimulation. Children can build substantial homes for animals from soft pine boxes. Guinea pigs, mice, rats, rabbits, chickens, animals with which many children have had little contact in their homes, can be nicely housed in simple cages which children can make. The daily and accurate observation and care of these little animals will develop in the children an attitude of respect and appreciation for all animals and will furnish them with first-hand information which cannot be gained from books or from the teacher.

Terraria and aquaria. A well balanced aquarium where fish life can be studied is always a source of interest. Likewise, terraria for observing the turtle and the snake, for watching worms and insects should be provided. Children should always find in the science room an adequate place to house the specimens they bring. Large paste jars which have been emptied may be used for this purpose. The responsibility for the food, for fresh water, and for the cleanliness of the houses should be assumed by the children. Contact with animals at an early age may lead to a permanent interest in and appreciation of animal life.

Environmental materials. There is no need for expensive

equipment in a primary science room, for children furnish many of the materials needed. Large sheets of oak tag for charts, for keeping a diary of an animal or a plant, for recording an experiment, and for labeling specimens should be available as a permanent supply for science projects.

Of course, the usual supplies of paints, hammers, nails, files, saws, art paper, easels, are necessary supplements to a science class.

B. Activities of the Primary Science Program

Reporting individual observation. As children's interests vary, so will their observations vary. An excellent plan to encourage the individualized observation is to provide a part of each period for a discussion of what they have seen or of what they have found or read. Every "find" is important. If the observation proves to be one of only momentary interest, it can be nicely taken care of without injuring the feelings of the child. If the interest is quite general it may lead into a worthwhile study.

In the kindergarten and first grade the observations will be very simple in nature. As children are trained in observing, their observations become more specialized and because of the attention given to this type of observing, we find that by the third grade the child will have acquired a more scientific attitude and will have learned better how to discriminate and to select what is interesting to report to the class.

Planned classroom observation. Planned observation is commonly utilized in the science classroom. A first grade teacher ends the day with a newspaper report. The daily weather report is a necessary item of every newspaper. Many science facts will be recorded at this time.

In the third grade attention is called to the many usual interests around the school, the speedy mowing of the great expanse of lawn, the raising of the flag on the school grounds, the trees and bushes that are found on the campus, the turning of the whirl-i-gig on its axle, and the balancing of the see-saws. All such simple observations can become the source of conversation and inquiry if encouraged by a far-sighted teacher who knows definitely in what direction a planned observation can evolve.

A third grade class followed most intelligently a parsley-caterpillar that was brought in. The children listed the points

which they wanted to observe. The points were typed and tacked to the breeding cage. Guiding questions led to intelligent observation. The children were encouraged to keep records of their observations. Sometimes this was done by a series of sketches. Many facts were learned through this observation.

Trips. The schoolroom should be the "world" in an elementary science program. The vital out-of-doors furnishes much of the content for the elementary science program.

A first grade takes a trip to the field or garden to see the grasshoppers. Soon they are discovering and learning about the cricket, the bee, the ant, the moth and other insects. The first grade child eagerly follows his shadow on the playground in the morning, at noon and after school. He makes his shadow run with him, skip with him, jump and walk with him. He goes outside on a windy day to see what pranks the wind will do to him, to the leaves, and to the clothes on the line.

The second grade child will learn to analyze in a more organized fashion. He observes the results of wind direction. He visits the lake in the fall to watch the wild ducks and to notice when they begin to migrate. In the spring he goes to the stream to collect frog eggs. He watches the growth of gardens in the community.

A field trip need not necessarily mean a visit to a lake or to an electric company or to a field. To one third grade it meant twenty minutes on the school campus with a real purpose in mind.

A field trip when purposed and planned will become a meaningful experience rather than a hilarious adventure.

Demonstrations and experiments. You visit a science class and the questions raised by the children will usually begin with "Why is such a thing true?" or "How can such a thing happen?" or "What makes it happen?" The answer to the *why* and *how* and *what* will be "Watch and see what you discover" or "You try it and tell us what happens." No other class affords the opportunity for "doing" as does the science class. Even the "simple doings" in the kindergarten and first grade lead to discoveries.

Little Ann brings her doll buggy to school. She discovers what makes it move, something she has never noted before. Ned brings his wagon. He loads it with blocks and discovers it is difficult to pull. Ned tries to pull it over a rough surface and soon discovers it pulls easier over a smooth surface.

The children in grade two discover that solids may be changed into liquids and that the liquids may be changed into solids. They discover what happens when they heat ice or lard or put sugar in water. Again they discover how a liquid may change into vapor form. Great joy comes to each little second grade child when he has actually carried through the experiment for himself.

A group in grade three, in connection with its study of growing things, wanted to know where the "seeds" of the mushroom were to be found. In order to answer this question the children experimented with the making of spore prints.

Visual supplements. In the lower grades the opaque projector is the favored machine. Pictures collected from magazines, books and papers are mounted for use. Among other subjects we now have pictures of insects, reptiles, birds, moving things, wind antics, weather, machines and stars. Our collection is constantly growing. A few slides on birds and insects are simple enough for use in the lower grades. Films on pets, bird homes, wild animals, and simple machines, have been found to be sufficiently elementary.

Reading for information. Very few science books are available for young children to use in solving their science problems. Beginning with the second grade, reading becomes a much used tool for the science experiences. Since children like to make their own stories, a teacher can make use of this interest to accumulate materials. In the first grade, hectographed or mimeographed copies of the chart stories may be illustrated and will make excellent reading material to be used the years following in any first grade. In grades two and three, individual stories built around different units studied will contain original characteristics which make most interesting reading in years to follow.

Perhaps the one plea which should be made for science reading is to avoid that type of material which clothes scientific information in fictional disguise, claiming that it is of greater interest to the little child. Children read this material to get information and the information does not need the "fanciful tale" idea to be interesting. The newer material in the market is telling science facts in a direct, forceful manner.

C. Testing

Since a science program fosters thoughtful awareness of the

beauty, usefulness, orderliness, and simplicity of the laws which govern our surroundings, we are attempting to find out as objectively as we can how far we have travelled toward this goal. Types of tests to discover how discerning little children are and to discover what application they make of concepts are in the process of being developed in our schools.

D. Conclusion

A science program in the primary grades will become functional not when a special set-up with expensive equipment is furnished, not when courses of study are available to furnish ideas, but when an understanding teacher, who loves to discover for herself, institutes the program. This teacher will not need elaborate equipment because her interests and encouragement will influence children to make many contributions. The one essential is a teacher's will to initiate a science program and to want it to succeed.

NEW APPARATUS AND MATERIAL FOR THE TEACHING OF PHYSICS*

A. H. Gould
Boys' Technical High School, Milwaukee, Wisconsin

The longer I teach physics the more I feel the need of unifying the subject by pointing out to the student on every possible occasion the great law of nature that serves as a massive cable supporting all physical phenomena. Personally, I feel the greatest satisfaction in that equipment which lends itself best to this attempt in the field of pure physics. I realize, on the other hand, that we must, of necessity, introduce a certain amount of engineering of a light nature into the subject and that a part of our apparatus must be chosen with this in mind. But all such pieces may not be regarded as having permanent value. I have on my shelf a fine model of a Corliss engine. It now has little value as a demonstration piece. Our science is a fairly fixed thing but not so the art.

The subject of inertia is important. We should make the student understand that if nature failed to introduce this mys-

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* A paper from the Physics Section of the Central Association of Science and Mathematics Teachers, November 29, 1938.

terious principle the major law would break. Many of us have neglected the use of some inertia apparatus in the past because of the mechanical difficulties inherent in it. For my own part I have been using the steel track and car outfit but I have for some time dispensed with vibrating pens tracing on paper in favor of a scheme whereby two electromagnets in series release simultaneously the weight-driven car on its track and a steel ball from the ceiling and the car is timed to break another circuit at the end of its run, giving a single blow on a bell, this sound to synchronize with that of the ball hitting the floor. Crude as it may sound, it gives fairly accurate results in checking Newton's second law of motion. But there is available now a new arrangement for clocking the car that is simple in conception and operation and gives accurate results. The car carries a vertical mast which emits a spark at regular intervals to mark a horizontal strip of paper stretched above it.

Every decade the world takes a more worried survey of its dwindling energy resources. One device that has considerable promise in the way of getting energy from the wind is the rotor tower. You can now get a model of this mounted on a small car for demonstration on the steel track. An electric fan will furnish the wind power.

I once asked a group of science teachers to account for the energy removed from a rolling automobile which is brought to a stop by a man pushing against it as he backs away. The naïvete of my question got me only some tolerant laughter and the advice to consider the fact that food energy is turned to heat in the man's muscles. On the other hand I have often precipitated a worth-while discussion in a class of students by getting a strong boy to pit himself against a little model of a commercial lifting electromagnet connected to a single dry cell. Which is the more powerful, the boy or the cell? The easy thinkers answer in chorus but some of the better heads, after a little reflection refer back to the formula of force times ~~space~~ distance. The new and powerful alloy magnets offer more than amusement. The sight of one magnet floating in space above another should rouse interest in the dullest student. And a line of such powerful bar magnets hanging vertically with bifilar suspension make a fine demonstration of wave propogation. Supporting collars for this are available. One new horsehoe magnet of steel alloyed with nickel, cobalt, and aluminum will support fifty times its own weight.

I think that we should present, as a unit lesson or demonstration, man's several methods of obtaining electrical energy by conversion from other forms. Now we can obtain a large Rochelle crystal mounted with a neon lamp which flashes when a blow is given the crystal from a rubber mallet. A phonograph needle can be quickly clamped to the upper end and the modern phonograph pick-up demonstrated if the crystal leads supply the audio amplifier of a radio instead of the neon lamp. With a disc replacing the needle you have a model of the crystal microphone.

Text books, it seems to me, touch altogether too lightly on the very important subject of resonance in the various fields of energy. Apparatus is limited here. Frahm's resonance top in not a distinctly new thing but I am impelled to mention it here as an excellent device for showing resonance in machines. It will have special significance to any driver who has happened to lose a blade off his fan at high speed. In the field of sound we have the matched musical bars that give fine results; and in radio there is the short-wave demonstration outfit that has been on the market for a number of years. With this last piece of apparatus it is no longer necessary to string out long wires to show standing waves with the use of a neon lamp. A comparatively short coil can now be used to advantage. And a laboratory lacking funds for this short-wave transmitter and the wave meter to be used as a receiver can secure a new, modernized, and efficient form of the Hertzian oscillator at a reasonable figure.

In the field of visual education new sound films are appearing that look very interesting. Some of them I know to be fine. But personally I believe that the slide is vitally important in the teaching of physics and I shall continue to add to my already large collection. Recently I was pleased to find that I was not alone in this peculiar view. The physics department of one of our leading universities announced themselves strongly in favor of slides but found themselves confronted with the difficulty of getting slides that they considered suitable. There is a core of material here that may be picked up but one is likely to get antiquated material if he is not careful. I have made a large part of my own from line drawings. illustrations, and photographs. And how often I have wished some one would put out a good slide making camera, designed for speed and efficiency in this field of copy work.

A year or so ago the Chicago Apparatus Company published a free pamphlet with some excellent line drawings on the principles of flight and these make good slide material.

There is a new service available that should make the work of slide collection easier. Write to the library of the United States Department of Agriculture and ask for order blanks and information on their bibliofilm service. You will find that they will photograph on 35 millimeter film any article, illustrations and all, from most of the magazines and texts. These can be transferred to your own film or "blown up" by projection onto glass slides.

If you write to the publicity departments of our two biggest electrical companies you will get a list of their film slide strips and movie films. Some of the film slide strips are excellent, particularly that on the history of the electrical industry and the one on recent developments in the electrical field. The latter strip is brought up to date occasionally. The film strips are accompanied by manuscripts and are free of objectionable advertising. The moving picture films are rent free and the strips are given to schools.

One company offers two new thermometers. One is a bolometer with a dial of one and three-quarters inches and the other a red-liquid thermometer of long range visibility and an accuracy equal to that of the mercury type.

Have you noticed the apparatus for demonstrating the synchronous and the induction motors. Using battery power it shows an actual revolving field in a multipolar stator and the development of torque by induction in an aluminum can rotor. It is a good piece but would be improved by a more-true-to-type synchronous rotor. While we are on the subject, why hasn't some company given us the synchronous and the induction motor in a fractional horsepower size suitable for the laboratory and dissectable yet fool-proof in design?

In the matter of ultra-violet demonstration one is a bit bewildered by the array of sources already offered and a new lamp is about to appear on the market. I have tried out most of them and find that one will be disappointed if he hopes to show anything spectacular in full daylight. If you want my advice I should say the best scheme is to use one of the screened mercury glow lamps in series with the reactor one company furnishes for it and a reflector behind it. Mount the lamp in a good-sized box with a fur-framed hole for the face. Have the lamp below

the face level and directed at the face with a mirror opposite the face. The lamp is made with "Corex" glass and emits very little visible light but if one looks into the darkened box, opens his eyes wide, and shows his teeth at himself he gets an image that is really startling. If you have facilities for darkening your room you can get results with trick paintings.

Probably many of you have used for years the simple spectroscope with the ruled grating at the eyepiece and a scaled background upon which the spectrum is seen. This may not do for the university but I feel that it meets the needs of the high school student. By flipping the cover up and down he can get the reading of a line of fair intensity if we don't worry about accuracy to the sixth significant figure. He can see a few of the Fraunhofer lines in the sun's spectrum and compare this spectrum with that of the carbon arc. For line spectra let him view the sodium flame, the lithium flame, the mercury lamp, and the new neon glow lamp with the eyepiece and the slit in line to scan the velvet-like glow about the electrodes. Heretofore the mercury lamp was a problem. The mercury arc was too expensive and dangerous and the high-voltage tubes had electrodes that overheated and confused the spectrum. But the new 110 volt, 15 watt, mercury tube light solves that difficulty nicely. It plugs directly into the line and operates at very high efficiency. It is a combination of tungsten and arc like the S1 sun lamp but adapted to tubular form.

There is one subject in physics that stands above all others in its appeal to the imagination, in its tremendous significance in the complex pattern of the universe, in its vast breadth and diversity that is comparable to nothing else that touches the mind of man. Yet some texts give it a short, dry paragraph. I refer to the electromagnetic spectrum. And now we have Compton's chart to show visually something of the wonder and romance of the phenomenon. It is of large size with the electromagnetic spectrum laid out horizontally, the source of each portion shown above and the means of detection and the applications pictured below. The narrow belt of the visible spectrum is shown dispersed into a colored spectrum beneath. Altogether, it is splendidly done and an excellent teaching aid.

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

WHAT SEEMS TO BE AHEAD?

Otis W. Caldwell
General Secretary, American Association for the Advancement of Science

Experimentation is the method of improving education, most likely to prove useful. This assertion is supported by tested results in a considerable number of institutions, and in the work of many individuals. An experiment involves a planned effort to give careful trial to something that is designed to improve existing practices. Such possible improvements may relate to any part, or to the whole program of an institution. From a scientist's point of view, an experiment does not ordinarily involve a whole program but deals with a separate unit or item which may be measured so that substantial and reliable evidence may be secured. Results regarding one unit may be changed somewhat by later experimentation on related units. But when an entire school program is announced as the object of an experiment, extreme caution is needed. Thus we have sometimes heard platform pronouncements of educational philosophies that were claimed to reconstruct entire school programs. Good scientists, even, have made such claims when outside the fields of their own special knowledge. Such pronouncements may omit the many specific component units or practices which need careful experimentation before such general claims may have any considerable true foundation. During the last two decades we have had all sorts of assertions regarding the ways in which science should be used in education. There have been advocates of so-called freedom; of having each pupil do only what he then likes to do; of having an educational program made specially for each pupil, often made largely by the pupil himself and by groups of pupils who advise the teacher of their decisions as to what they will study; of activity programs which I fear are too often marked more by vigorous activity than by clear purpose.

Experimentation is or should be based upon some sort of hypothesis or philosophy regarding the field of the proposed work. Bearing upon educational philosophy is a recently published volume which is here cited as a highly significant part of the foundation for certain comments I wish later to make. It is Dr. John Dewey's *Experience and Education* (The Macmillan Company, 1938. $1.25).

This eminent leader in educational philosophy has probably been quoted and misquoted more than any other one regarding reorganization of science as well as other subjects and practices of schools. Now comes this latest volume in which its author clearly opposes "hit and miss" experiences as a basis for education, but urges continuous and cumulative organization of subjects and of planned experiences for educational uses. He makes intelligent fun of the extremely left-wingish idea that teachers must not be leading factors in deciding what is to be studied and how it is to be studied. He clearly indicates that his philosophy does not leave everything to the transient whims of groups of uneducated pupils, nor to sprightly teachers who may be earnest, but weak in scholarship or in professional technique. This latest little volume will doubtless prove opportune by providing a better balance between extreme progressives and equally extreme conservatives. One can readily guess that Dr. Dewey, the unmatched stimulator of educational thought, has found it harder to lead and guide his friends than it has been to protect himself from attacks by his opponents. It is also clear that those of us who have steadily urged moderation in adoption of the latest educational slogan, will now find satisfaction in Dr. Dewey's advocacy of orderliness and the essentially cumulative nature of any education that is worthy of our efforts. One thing that seems almost certainly ahead of us is a slowing-down or even withdrawal of the most active educational skirmish lines, while we reexamine and possibly consolidate gains already made in educational philosophy and practice. This applies to science quite as much as to other school subjects.

Ten years ago I formulated a plan for securing any discernable evidence regarding the results from so-called experimental ventures in education as compared with traditional procedures. This formation related to other subjects as well as science and in commenting now upon this study, it is necessary to speak of some aspects besides science. After making the preliminary outline of the plan and after securing the funds to set up the study, the next step was to find someone with interest, capacity and technical training fitting him for the task. From the list of recommended candidates, Dr. J. Wayne Wrightstone was selected. An advisory committee was organized. Dr. Wrightstone has been fully responsible for the proposed check-up. For six years he has been engaged in devising and using new-type tests by means of which to measure many specific aspects of experi-

mental work. The accumulation of results from specific tests makes it possible to give certain tentative conclusions of a comparative nature regarding whole school programs. In 1935 a volume was published entitled *Appraisal of Newer Practices in Selected Public Schools*. This entire edition was soon exhausted. Two later volumes have been published; in 1936, *Experimental High School Practices*, and in 1938, *Appraisal of Newer Elementary School Practices* (Bureau of Publications, Teachers College, Columbia University, $2.25).

It is not possible nor desirable at this time to present a detailed review of these publications. In making statements drawn from these reports it needs to be clear that Dr. Wrightstone constantly says that the conclusions must be regarded as tentative awaiting further investigations, since his sampling in elementary schools aggregated a total of but 180 pupils. The following paragraph is quoted as a summary of the accepted philosophy of the experimental schools used in this comparative study.

"The typical newer practices in the elementary schools are based upon an educational theory which has evolved from a number of hypotheses. Among these are the belief that the classroom is a form of democratic social life by means of which children reconstruct their experiences, that these experiences grow from children's social activities which may be integrated around central problems suggested by social activities, that pupil's interests are signs and symptoms of growing powers and abilities, that interests and powers are developed by activities rather than by passive assimilation of knowledge, and that education is the foundation of social progress and reform. There is no fixed succession of subject in the grades of newer schools."

Now what are the comparative results in the three elementary grades in reading, spelling, language and arithmetic? The newer type schools are slightly higher in all four subjects than the conventional schools. In the three upper elementary grades the newer type schools surpass by about eight per cent in language, and are not below, but not significantly above, in reading and arithmetic, the ranks in spelling not being included. In the types of abilities called "obtaining facts," "explaining facts," and "applying facts" the differences are not significant, but the experimental schools are slightly superior. In outside interests—shop tools, pets, collections, and reading the experimental schools surpassed distinctly. In physical and mental

hygiene experimental schools were superior but not markedly, except in the category called "physical fitness." In information about environmental, social, economic, and aesthetic matters, experimental schools were superior. In the small amount of testing that related to elementary science, experimental schools were superior though again the results are hardly significant.

From the volume dealing with high schools the following conclusions are drawn relative to the sciences. In recall of factual information in general science, biology, physics and chemistry, the experimental schools surpass, the difference being small in general science and biology, and distinctive (18% and 33%) in physics and chemistry. In interpreting and applying facts the experimental schools surpass slightly. In knowledge of unfounded belief experimental schools are distinctly superior. In self-initiated and cooperative activities, both as to number and quality, experimental schools surpass by more than 30%, but in ability in recitation the conventional schools surpass by 50%. In personal and social adjustment no distinctive difference was shown.

The fact that the experimental schools used in this study regularly surpass the conventional schools used in this study is suggestive and encouraging, but not overwhelmingly convincing. So far as science is concerned, the results hardly justify a hasty rush to the methods of newer-type schools, unless self-initiated activities, and knowledge of unfounded beliefs are matters of deciding importance.

We cannot be complacent, however, and say that our ordinary teaching is good simply because experimental schools are not shown to be decidedly superior. As to usable facts learned, as to attitudes we regard as desirable, in ability to use data, experimental schools are slightly superior. But almost as good may still be bad.

Dr. Homer C. Sampson of Ohio State University has made a study, unpublished as yet, from which he has granted me permission to make selections. Dr. Sampson, and those working with him have studied the records of 826 college freshmen in botany, of these almost exactly half had studied biology in high school and half had not. The grades made in college by these students seemed to bear no helpful relation to whether they had studied biology in high school. In tests regarding personification of plants the high school biology group made 999 errors, the non-biology group 851 errors. In drawing inference from

facts the high school biology group made 1008 errors, the other group, 772 errors. In recognition of misstatements regarding evolution the high school biology group made 1188 errors, the other group, 785 errors. This surely is an indictment of biology teaching in the schools from which those students came.

What should be ahead of us, if the statements made are reasonably representative? Can we adopt the programs of experimental schools and thus secure the needed advances? That is not fully proved by convincing tested results. Is the present teaching good enough? Surely the Ohio State University study does not indicate it.

The job is harder and bigger than we have realized and needs a new kind of experimentation dealing with no end of detailed problems each followed until proved results are available. It seems probable that coherent and cumulative and much more careful teaching is needed all through the schools. We have been in the habit of advocating shibboleths, slogans, quick methods of meeting the intricate problems, and those do not help us much. We must recognize the magnitude of the problem and organize for a much longer and more exacting series of really scientific studies of science teaching. Our educational philosophy must be better balanced so as to include the useful things we have learned, and commit us to moving on slowly and not by treating wishing as if it were a guiding philosophy.

CHEMISTRY CONFERENCE AT THE UNIVERSITY OF VERMONT

The New England Association of Chemistry Teachers, now in its fortieth year of continuous activity, is to hold a summer conference at the University of Vermont, August 16–19, inclusive. The purposes of the conference are to assimilate new material in teaching form, provide for ample discussion, and to develop closer professional and personal relationship among chemistry teachers. Already many of the leading college and secondary instructors have signified their intention of being present. The program themes include:

The Introductory College Chemistry Course
College-Secondary Chemistry Relationships
Assimilation of New Material in Teaching Form
The Consumer Aspect of Chemistry Teaching

Registration, $2.00, is the only cost to members in addition to living expense which will be modest. Non-members are invited to attend on the same basis as members: viz., $2.00 registration, and $3.00 for a year's membership in the NEACT, including a subscription to the REPORTS.

For further details and program, write Elbert C. Weaver, Chairman Summer Conference Committee, Bulkeley High School, Hartford, Connecticut.

AN EXPERIMENT WITH A DIFFERENT TEXTBOOK

E. D. Burton
Shortridge High School, Indianapolis, Indiana

In September, 1937, we designated one class in Geometry I as an experimental class. This class was not selected in any way according to ability but was a run-of-the-mine group which happened to be assigned to Geometry I, Period 2—Room 335.

The book used in this class was John A. Swenson's ***Integrated Mathematics with Special Application to Plane Geometry.*** It is Book II of the series. Book I is for the ninth grade.

The class was kept together for one year, two semesters. Since the class had not had Book I of the series, we could not use all the material in the book and omitted chapters 3, 7, and 9, which deal with Cartesian Geometry and third and fourth dimensions. This is not the place to write an extensive review of the book. I am merely reporting results. Perhaps I should take time to say that this book is, as the name indicates, integrated mathematics. Algebra, trigonometry, and analytic geometry are used and applied to plane geometry.

The class liked the book and worked diligently at it. Exercises in it are such that everyone in the class can do some of them. There are also exercises to test the bright student. I have never seen Mr. Swenson teach and probably did not get the same results as he would from the same course.

At the end of the year we decided to make some attempt to measure results. We selected another class in Geometry II, which had used the regular textbook. We tried to compare the two classes.

To each class we gave two forty-minute tests. One test was to answer twenty-five questions which required knowledge of geometric theorems and some use of arithmetic and algebra, but no trigonometry. The other test was to write four formal

Swenson Class			Other Class		
Average I.Q.	Average number of problems right	Average number of proofs completed	Average I.Q.	Average number of problems right	Average number of proofs completed
106.18	10.66	1.1	111.68	6.58	2.02

proofs of theorems. The questions could be scored as right or wrong. Theorems were marked either right or half-right. Results are shown in the table on the preceding page.

The experiment was not extensive enough to draw any valid conclusion. My own notion is that it shows one can teach more or less what he tries to teach.

The pupils in the Swenson class did not practice writing formal proofs. Theorems were proved formally but orally in class and problems requiring their application were assigned for home work.

Pupils in the Swenson class had also been exposed to quite a bit of algebra and trigonometry which could not be used in testing the other class.

I am appending a list of questions used and a table showing I.Q. and scores for each pupil in each class. This table really contains the gist of this report.

Revised list 25—so each counts 4 per cent

1. In a circle minor arc pq is $\frac{4}{5}$ as large as major arc pq. How many degrees in the major arc? Ans.____________
2. If $4x$ plus $7 = 10$, $4x$ plus $3 = ?$ Ans.____________
3. State the axiom involved in #2.____________
4. If one line meets another so the adjacent $\angle$s are equal, the lines are ____________.
5. Two complementary $\angle$s are in the ratio $2:3$. How many degrees in the smaller?____________
6. If the bisector of an $\angle$ of a $\triangle$ is $\perp$ to the opposite side the $\triangle$ is ____________.
7. If one $\angle$ of a $\triangle$ is $52°$ and the other is $76°$ the $\triangle$ is____________.
8. In a given rt. $\triangle$ the hypotenuse is $2K$ and one side is K. How many degrees in the smallest angle? Ans.____________
9. How many sides has a regular polygon if each exterior $\angle$ is $72°$? Ans.____________
10. Solve, for n, $i = \dfrac{180\ (n-2)}{n}$ Ans. $n =$____________
11. In $\triangle ABC$, $\angle A = 27°$, $\angle B = 80°$. Arrange the sides a, b, c in ascend-

ing order of magnitude. Ans.__________

12. How many points could be located 2″ from line L and 3″ from line L' if L and L' intersect? Ans.__________

13. The area of a rectangle is 45 sq. in. and the width is 20 per cent less than the length. How long is it? Ans.__________

14. The area of a rhombus is 48 sq. in. and one diagonal is 50 per cent longer than the other. How long is the short diagonal? Ans.__________

Swenson Class				Other Class			
Pupil Number	I.Q.	Problems Test I	Formal Proofs II	Pupil Number	I.Q.	Problems Test I	Formal Proofs II
1	126	17	3.5	1	127	11	3.5
2	128	15	2.	2	124	10	3.
3	109	15	1.	3	113	9	2.
4	123	15	3.	4	128	9	2.
5	110	14	1.5	5	110	8	1.5
6	92	14	0	6	124	8	3.5
7	115	13	1.	7	104	8	3.
8	110	13	0	8	115	8	3.5
9	115	12	1.5	9	123	8	1.
10	114	12	2.	10	116	8	3.
11	105	11	1.5	11	113	8	3.
12	111	11	1.5	12	111	8	2.
13	86	11	0	13	121	8	2.
14	116	10	Absent	14	118	7	1.5
15	90	10	Absent	15	92	7	.5
16	113	10	0	16	124	7	3.
17	86	10	.5	17	117	7	4.
18	102	10	2.	18	102	7	1.
19	88	9	0	19	101	6	1.
20	109	9	1.5	20	116	6	3.
21	104	8	0	21	110	5	2.5
22	86	7	0	22	109	4	1.
23	101	7	.5	23	99	4	1.
24	101	7	0	24	108	4	1.5
25	95	6	1.5	25	112	4	3.
26	121	6	.5	26	96	4	0
27	111	6	2.5	27	112	4	2.
	2867 Average 106.18	288 Average 10.66	27.5 Average 1.1	28	101	3	0
				29	93	1	.5
					3239 Average 111.68	191 Average 6.58	58.5 Average 2.02

15. The sides of a △ are 2.1, 2.8, 3.5. Find the area.____________________

16. The sides of a rt. △ are 30, 40, and 50 ft. Find the length of the altitude on the hypotenuse. Ans.____________________

17. One base of a trapezoid is double the other. The altitude is 10 and the area is 75. Length of short base = ____________________.

18. Find the 4th proportional to $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$.
Ans.____________________

19. One ∠ of a rt. △ is 20° and an ∠ of another rt. △ is 70°. The △s are ____________________.

20. In a rt. △ the altitude to the hypotenuse divides the hypotenuse into segments 4″ and 9″. How long is the altitude?____________________

21. The arms of a rt. △ are in the ratio 3:4 and the hypotenuse is 25. The short side is____________________.

22. How long is one side of a square whose diagonal is 10″?
Ans.____________________

23. Find the area of a △ whose sides are 7, 15, and 20.____________________

24. Two corresponding sides of 2∼△s are 2 and 6. Find the ratio of their areas. ____________________

25. The hypotenuse of a rt. △ is 17″ and one arm is 8″. How many square inches in the area. Ans.____________________

SUMMER SCIENCE FORUM

A science forum will be held at Syracuse University on July 20. This conference is a feature of the summer session and the progressive education workshop at Syracuse. It is under the direction of a joint committee of the School of Education and the Division of Science of the University. The general theme is "The Future Science Program for Citizenship."

Anyone who wishes additional announcements or information may obtain such by addressing J. Wallace Page, Syracuse University, Syracuse, New York.

There is no work of genius which has not been the delight of mankind.

ENRICHING NATURE STUDY, ESPECIALLY IN A UNIVERSITY COMMUNITY

CATHERINE N. DOBBIN
Cornell University, Ithaca, New York

The fact that a new course of study for nature education was being worked out for the Ithaca, New York, public schools suggested the idea that there would be a wealth of interesting and unique local material which could be incorporated if time were taken to search it out. Professor E. L. Palmer of the Department of Rural Education of Cornell University suggested to the author that she devote some time to this work. The research proved to be most interesting, even fascinating in some respects.

Ithaca is especially fortunate in having within its bounds Cornell University, from which has emanated a great deal of research concerning the local region. Cornell has had many professors whose work in certain fields has been outstanding. With this in view a search was made through college publications as well as others which concerned the region more or less directly. Many of the sources of reference could be used in other communities, some are particularly useful in a university town. In brief they are as follows:

1. College faculty publications, popular works or the more technical ones.
2. Experiment station bulletins or extension bulletins.
3. Theses of graduate students.
4. Interviews with professors or other people of the town.
5. Popular student body publications.
6. Early histories of the town or surrounding country.
7. Newspapers, especially memorial editions.
8. State museum reports.
9. Geological survey reports.
10. Biological or stream survey reports.
11. Public health reports.

A search was made through all of the lists of publications of the faculty members of the university as listed in the presidents' reports from 1881 to 1937. Anything that seemed at all significant was looked up in the library and was scanned for pertinent facts.

A similar search was made through all of the theses in the Cornell University library. Any of them concerning research unique for Ithaca was noted. All of those treating life histories

were listed so that they could be referred to by any teachers who might be interested.

The Cornell University Agricultural Experiment Station Bulletins from 1880 to 1938 were also examined for material. They as a rule are not restricted to small local areas, such as the Ithaca region, but they do offer a convenient and inexpensive source of supplementary material concerning living things or situations which are found here as well as elsewhere. The same may be said of the publications of neighboring states, for the findings in adjacent regions may be applicable here. A list of all of the Cornell Experiment Station bulletins which might be of use in helping one find facts concerning the life history, distribution and control of insects, plant diseases, and weeds were listed along with the theses for reference.

A perusal of early writings concerning Ithaca, or the region before Ithaca existed, revealed much that could be applied in nature study. The notes of John Bartram as he travelled through on his botanical quests and the notes of members of the Sullivan expedition give us information as to the fauna and flora of the region in early days. Later writings about the town show us why and how it grew. Publications concerning the early history of Cornell University were also useful. The writings of the first president, Andrew D. White, and the biography of the founder, Ezra Cornell, added scenes to the picture. Addresses given at the dedication of numerous memorials about the campus were of use. Reports of the *Cornellian Council* and *The Cornell Era*, campus publications, contain feature articles which proved applicable.

A search was made through the public health reports of Ithaca. These revealed interesting facts in relation to the past and present sanitation and water supply, about epidemics, and public health in general.

Memorial editions of the *Ithaca Daily Journal* contributed a considerable amount. Early history, development of industries, of transportation, of power and light, of municipal projects such as parks and sanctuaries, were all discussed.

Reports of the state museum, of the geological survey, and of the biological or stream survey were valuable in many respects.

Suggestions of individuals who knew the city and its history rather well were gratefully accepted. A visit to the city hall also proved to have possibilities.

Features which would enrich all the phases of science, geological, biological, chemical, physical, astronomical, et cetera, were sought out. A few of them will be mentioned here, but space will limit them to a very few.

The very name of diamonds seems to have a sound of glamour and intrigue, and so to children it is quite thrilling that there may be a possibility of the occurrence of diamonds right in Tompkins County. There are numerous dikes in the region, and when this formerly molten lava came in contact with the carbonaceous shales, it is not impossible that diamonds were formed as they were in the Kimberley region of South Africa. The lava rock here is exactly the same kind as that at Kimberley. This is not the only possibility. There may be diamonds scattered about here anywhere, for the Ice Age glacier is known to have carried diamonds down from some unknown region in Canada, and left them scattered in its deposits like needles in a haystack. Several good stones have been found in the Middle West, but none so far in this vicinity.

The geologic history of the region is complex. For long ages this area was covered by a sea. During one of a number of times when the sea took a recess, a desert climate came. Numerous basins of landlocked salt water gradually evaporated and left their deposits of salt. This process was repeated again and again, and then, later the salt was sealed off by new rocks. One of these deposits lies on the east side of Cayuga Lake where a double tube well is sunk 1,800 feet or more to the salt beds which are 300 feet thick.

Deposits of limestone are found, too, notably near Portland Point on Cayuga Lake. This Tully limestone and the underlying Hamilton shale is used as the raw material for cement. Glacial erosion has removed practically all of the weathered rock materials, and the almost complete absence of residual clay in joint and bedding planes makes unnecessary the washing operation that is necessary in some cement quarries of the United States that are located outside the zone of notable glacial erosion. The limestone is 18 inches thick at the quarry. It is significant that the shale is below the limestone, for if it were above, the cost of removal and timbering would make the enterprise much less profitable.

The Finger Lakes region with its spectacular gorges and waterfalls has fame throughout the country both for its scenic beauty and for the recreational possibilities it offers. It was the

glacier which was largely responsible for this. The ice came from the north and at one time buried what is now the main street of town to a depth of 3,000 feet. It rounded off the hills, gouged out the already existing north and south river valleys and left "hanging valleys" of the tributaries from which come the present-day waterfalls. In some places Cayuga Lake was made four hundred feet deep, the bottom being fifty feet below sea level.

The glacier transported an enormous cargo of rocks and boulders. Hence we find large glacial erratics scattered over the fields. A number of conspicuous ones are in or near the town. Some have been used for tombstones. One, on the university campus, has been erected as a memorial to Ralph S. Tarr, the physical geographer, whose geography texts were the standard ones in use over much of the country for many years. This boulder has been cut out as a seat on one side and on the other has been placed a bronze plaque bearing in relief the bust of Tarr and an inscription.

It was because of the fact that three creeks had built an alluvial fan on the east side of the valley that Ithaca was located where it is. Here the land was higher and drier. An Indian clearing had existed at that point and the first crops had been planted before white men came. The first dwelling built by white man was just north of the gorge of Cascadilla Creek where there was a considerable waterfall only a short distance upstream. Very early a crude flour mill was erected at the mouth of this gorge. Ithaca continued to grow because of its location. Cross routes had been caused by the glacier scooping out north and south channels, which the rivers had helped to wear down. Ithaca was in a through valley with the lake at one end. There was a convergence of highways from the south, southeast, northeast, and of course north on the lake. It was on a direct coal route from the anthracite fields to the Erie Canal. In later days when freight began to be transported more by railroads, Ithaca's location was a disadvantage. The railroad approach was not good because of the high hanging valleys. The main lines consequently avoided the town.

In days of early settlement much of the land was planted to wheat. Now but a small percentage is so used. Topography and climate are in part responsible for the decline in farming on uplands. With the advent of railroads, shipping points almost all concentrated in the north and south through valleys, the

levels of which are much below the hill farms. The slopes are very steep, due to glacial over-deepening of the valley troughs. Early roads often led straight up hills, so such bulk crops as potatoes, to which the soil is adapted, cannot be profitably produced. This topographical difficulty is also to be contended with in hauling market milk. The shortness and coolness of summer makes growing grain uncertain.

Fauna and flora of the region have become much modified since early days. A Jesuit missionary wrote in 1671 that every year in the vicinity of Cayuga more than one thousand deer were killed. At a certain place where there were some salt fountains, the Indians would spread a number of nets for pigeons, and from seven to eight hundred were often taken at a single stroke of the net. In 1823 a grand deer and wolf drive was organized in the southern part of the county, for "the repose of settlers is disturbed by the midnight howl of the wolf and the yell of the panther." In 1671 most of the land was forested, although some was burnt off annually by the Indians as "oak openings" for hunting purposes. From Ithaca south to the Susquehanna the forest was dense, tangled, practically unbroken. Now the remaining woods are confined mostly to farmers' woodlots. In the southern part of the county, much of the land that was cut over has been abandoned, as it proved no good for farming.

It is quite evident that lumbering has been carried on to an excess in many parts of the country. One of the unique and important results of the ancient lumber industry is found in the location and development of Cornell University. The university owes much of its financial endowment to this industry, for Ezra Cornell chose large tracts of forest in the west for the scrip granted him by the government. In later years, Cornell University took leading steps in educating the public to the wise and careful use of the forest. The beginning of education in forestry in the United States was made at Cornell when in 1898 the first instruction in America and probably in the Western Hemisphere was given.

The people of Ithaca have realized the obligation of conservation of other types of wild life also. The Cayuga Bird Club, of which Louis Agassiz Fuertes, the famous bird artist, was an ardent sponsor, got the city to set aside a part of Renwick park as a wild life preserve. The Fuertes Sanctuary at Stewart Park was established after Fuertes' death, but he had always wanted

it. Numerous other wild life preserves owned by the university are in the vicinity of Ithaca also.

The retreat of many kinds of water fowl and fish was destroyed when the city of Ithaca tried eliminating the swamp at the head of Cayuga Lake. The place had bred myriads of mosquitoes, however, which left malaria in their wake. For this reason, the upsetting of the balance of nature was justifiable, because man benefited more or less directly by relieving the suffering from malaria.

A large number of life histories have been worked out in this region. Those of the lamprey, cut-lips minnow, sculpin, tree sparrow, blackbird, flying squirrel, woodchuck, apple insects, tree borers and grape pests are but a few.

Many scientific expeditions have gone out from Cornell. In 1896 a trip was made to Greenland to study the geology, plants, insects, marine invertebrates and birds of a certain region. Dr. Richtmyer, with his timing device, accompanied in 1937 the expedition to the South Pacific for the purpose of photographing the eclipse of the sun. Dr. Allen with other members of the ornithology department have made trips for the purpose of preserving the voices of rare and disappearing birds on sound films. The botanist, Rowlee, went to South America in search of balsa wood. Dr. Whetzel went to Porto Rico to study plant rusts and smuts. A Cornellian, Ross Marvin, acting as scientist, accompanied the Peary expedition to the North Pole, and was the only person to lose his life on that endeavor. Interesting tales have been told concerning his death.

Food problems of domestic and wild animals have been worked on extensively in the various departments of the College of Agriculture. The department of Home Economics has devoted a great deal of time and research to nutrition problems of human adults and children. Many college bulletins concerning these findings have been published.

In the field of chemistry, we find that research has been done upon the types of soil in this locality, means of improving these soils, and the types of plants that will grow best in them. Two chemical industries, the salt works and the cement plant, have already been mentioned.

A new mirror coating process was developed at Cornell in 1931. This has revolutionized the making of astronomy mirrors. They reflect the ultra-violet rays of the stars and do not corrode.

In 1937 the largest portable telescope was completed here.

The instrument can be dismantled and carried by pack train or men. It was to be put atop a 12,600 foot peak near Flagstaff, Arizona, 1,000 feet higher than any telescope had been before.

There are a number of particular sounds heard daily in Ithaca which might be well worth studying. One is the blowing of a whistle which indicates the forecast for the weather, if one but knows the code. Another is the Cornell chimes, which peal out frequently. There are some notable pipe organs on the campus, also. In these uplands of New York is that mysterious, entrancing sound of the "lonesome drum." Apparently so characteristic to this region is it, and so intriguing to the imagination, that a book of folk tales and facts written about Central New York has been entitled, *Listen for a Lonesome Drum.*

The field of electricity has much of local interest. In fact the very existence of Cornell University is founded upon the telegraph, for it was in the Western Union Company that Ezra Cornell made his fortune. Indeed the practical success of the invention of the telegraph instrument was due largely to this man. On the campus is preserved the original telegraph instrument used in sending the first message "What hath God wrought?" from Baltimore to Washington. In 1875, the first dynamo constructed in the United States was built in the physics department of Cornell.

After this manner, one might go on at great length mentioning little items which help to make the study of elementary science more tangible and "close to home." Many sources of reference are at hand, but in closing, let us note again that those listed at the beginning of this article have been found to be particularly useful, especially in a university community.

AIRPLANE TESTER

The Lockheed Aircraft Corporation, builders of speedy transports and bombers and of the Army's new twin-engined pursuit plane, has just installed a 150-ton testing machine to put compression and tensile stresses as high as 300,000 pounds on airplane structures. It is believed the largest piece of machinery of its type in the United States.

It is a part of a $15,000 installation of testing machinery which gives the Lockheed company one of the most complete structures laboratories in the American aviation industry.

Book must follow sciences and not sciences book.

PROFESSOR WHIZ AND HIS CLASS IN MAGIC MATH

ADAH VAUGHN
Woodrow Wilson Junior High School, San Diego, California

This little skit may be added to any mathematics program. This particular one was given in an assembly where a Mathematics Club was having an open meeting, and Prof. Whiz with his class were invited to put on a special demonstration for the club.

The pupils like to work out their own costumes, such as gingham aprons, big ties, etc.

Portable blackboard, and high stools (borrowed from the mechanical drawing room) slates, sponges, help in the stage setting.

Prof. Whiz should be a good talker, able to give problems slowly and loudly so that the audience may grasp the problems.

Characters:

Prof. Whiz

The dunce—(with cap) His duty is to erase the board after problems, and be an errand boy in general.

Five pupils—	*Additional*
Beechnut	The club and its president
Hazelnut	Three stooges sitting in the club
Hickory nut	Mr. Pythagoras
Wagon nut	Mr. Euclid
Wallnut	Mr. Aristotle

(Any other favorite problem may be substituted or added to the ones given here.)

Prof. Whiz:—Mr. President, and members of the Mighty Masters Mathematical Club: I count myself happy to be here today and present my class in Magic Math. They are known as the greatest nut-crackers of all the world.

(Introduces the class. As each pupil hears his name called, he makes his own salute in his own style.)

At the left, far, far from me
Is a cracker of nuts who lives down by the sea.
Beechnut is his true and proper name,
Through math he'll reach the hall of fame.

Next is one with the pretty eyes,
All hard problems she defies.

We call her *Hazelnut* in class.
She really is a brilliant lass.

Next, sturdy and strong, a great delight
To teachers of boys who like to fight,
Is *Hickory nut,* who with greatest of ease
Can solve hard problems, if you please.

The pupil next one to the last
Can work hard problems quick and fast.
And 'cause she likes her tail-waggin' mut
She goes by the name of *Hickory nut.*

The big nut cracker, last in line
Might well be made of stone and lime,
For *Wallnut* is his name and title
No problem too hard for him to tackle.

Class:—(in chorus)
We're glad to meet you, one and all.
But we're not nuts, as you may think.
We only *crack* the nuts—that's all.

Prof. Whiz:—
Attention, class. Get out the slate
Add these problems at rapid rate.
Problem Number One.—What is $\frac{3}{7}$ chicken, plus
$\frac{2}{3}$ cat, plus $\frac{1}{2}$ goat?

Class:—(in chorus)
Oh, we know what the answer is,
It must be Chicago, Professor Whiz.

Prof. Whiz:—
Your answer bright amazes me.
Now, Beechnut, show us on the board
How $\frac{3}{7}$ chicken, plus $\frac{2}{3}$ cat, plus $\frac{1}{2}$ goat
Equals Chicago, that town remote.
(Beechnut runs to the board, and says aloud as she writes.)

Beechnut:—
C H I C K E N has 7 letters. $\frac{3}{7}$ chicken equals C H I
C A T has three letters. $\frac{2}{3}$ cat equals C A
G O A T has four letters. $\frac{1}{2}$ goat equals G O
C H I plus C A plus G O equals Chicago.
(returns to seat)

Prof. Whiz:—
Very well done
For problem one.
Now class, problem number two
Some more adding for you to do.
"*A thousand and one, and fifty twice*
Often is used to grind grain nice."
Hazelnut, please write this down
And show us how the answer is found.

Hazelnut:—(runs to the board and writes as she says aloud:)

a thousand	and one	and fifty twice
M	I	L L

Often is used to grind grain nice.

Wagon nut:—
Prof. Whiz, please let *me* have a problem hard to do
I know my adding through and through.

Prof. Whiz:—
Very well, Wagon nut, so bright,
Perhaps you'll do this one all right.
Take one digit, no more, no less.
Use it eight times. A thousand you'll get—or miss.

Wagon nut: (goes to board) (writes as she talks aloud)
I'll take the digit 8, and place it eight times thus,
Row by row. The answer comes to one thousand—so.

$$\begin{array}{r} 8 \\ 8 \\ 8 \\ 88 \\ 888 \\ \hline 1000 \end{array}$$

Prof. Whiz:—
You are good adders, one and all
Now in subtraction let no one fall.
From 45 take 45 and leave 45.
Wallnut take this problem to the board,
I'm very sure *you'll* not be floored.

Wallnut:—(works fast at board, subtracting rapidly and aloud)

9 8 7 6 5 4 3 2 1
1 2 3 4 5 6 7 8 9
8 6 4 1 9 7 5 3 2

Prof. Whiz:—But is that 45 from 45?

Wallnut:—Yes, Professor Whiz, it is. I'll show you.
(adds aloud the rows across. Each row adds to 45)

Prof. Whiz:—
Subtracted well, now for a harder one.
I'm sure you'll find it lots more fun.
Take 9 from 6—5 from 4,—and 50 from 40, and six will remain.
Who thinks that he this problem can explain?

Hickory nut: (runs to board and explains aloud as he writes)

From S I X	From I V	From X L
Take I X	Take V	Take L
Leaves S	Leaves I	Leaves X
S	I	X

Wallnut:—
Professor Whiz, I saw an odd design
Drawn with only one unbroken line.

Prof. Whiz:—
Very well, show us the figure now
Let's hope it won't look like a cow.

(Wallnut draws the figure shown on the following page. Talks as she draws)

Wallnut:—
See, I draw it without crossing a line,
Or going over one at any time.

Prof. Whiz:—(turns to president of club)
Mr. President, would any member of the club like to give a problem or two to my class?

(The president puts the question to the club. Calls for volunteers. The stooges respond.)

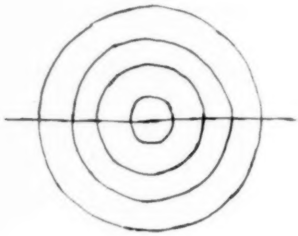
Mr. Euclid:—(recognized by the president)
If a man decides to save one cent the first day of the month,

two cents the second day, four cents the third day, and so on—doubling the amount saved each day, how much does he save in a month of 31 days?

Hickory nut:—(quick as a flash and loud and clear) \$21,474,856.47. Believe it or not!

Mr. Pythagoras:—What part of a million is ten hundred thousand?

Wallnut:—Ten hundred thousand is one whole million. Believe it or not!



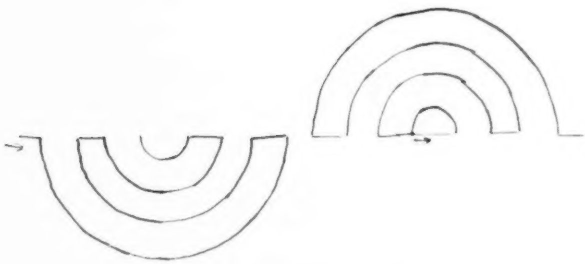


Figure drawn by Wallnut

How Wallnut drew the figure without crossing a line.

Mr. Aristotle:—If a bottle and a cork together cost 6 cents, and the bottle costs 5 cents more than the cork, how much does the cork cost?

Hazelnut:—The cork costs $\frac{1}{2}$ cent. Believe it or not.

Prof. Whiz:—Mr. President, we must hurry to our next engagement, but before we go, I want to leave a message for the Mighty Masters Mathematical Club. Knowing that all great mathematicians like to make and also to decipher codes, I have written the message in one of our own codes.

(The message which has been prepared beforehand, is as follows)

F N N C   K T B J

(The president thanks the professor, but looks at the writing in a puzzled way. Finally he asks for a cue.)

Prof. Whiz:—To decipher this code, substitute for each letter the one which immediately follows it in the alphabet.

(Beechnut runs to the board and points to each letter as the class helps her to decipher the code, aloud.)

Prof. Whiz:—
Good luck, and good bye
Say all the nut crackers and I.

(Shakes hands with the president, and leaves, saying as he looks back just before disappearing.)

Prof. Whiz:—
Thanks for inviting us here
Come and see us before the new year.

THE TEACHING OF CONSUMER CHEMISTRY*

M. C. Crew
Austin High School, Chicago, Illinois

When your chairman asked me to prepare and read this paper, I am sure that he understood, as well as I did when I accepted, that I am no authority on any kind of consumer instruction. But he knew that I had some interest in the matter and that I had undertaken in a small way to utilize it along with my regular course in high school chemistry. I am, therefore, going to tell you very simply of some of the things I have tried to do and some of the things we have done in the Austin High School along the lines of consumer chemistry.

This work is in no way a substitute for the regular course in chemistry. It is done as extra work. Sometimes it is extra reading followed by written reports, but more often it is some sort of a student experiment or investigation followed by a

* Read before the Chemistry Section of the Central Association of Science and Mathematics Teachers, November 25, 1938.

written report. During the second semester of chemistry I have always required, as a part of the course, that each pupil read on some topic during each marking period and write a paper of from six hundred to one thousand words on his selected subject. The paper is required to have a bibliography which contains some magazine articles as well as the usual encyclopedia references.

For the last two or three semesters, I have given pupils a choice in this matter of either writing the traditional paper or doing some extra experimental work on some consumer topic. For example, this semester during the first marking period there were twelve pupils working on consumer projects such as the following: coal analysis, that is proximate analysis of two or three coals commonly used for household fuel; comparison of several gasolines, according to the fractions distilled between various temperature ranges; analysis of household ammonia; analysis of some common bleaches; testing of soap for alkali; and a comparison of several water softeners; to list a few of this type. Others were working on samples of cloth to estimate percentage of wool and cotton by the usual alkaline test and making the report of these tests to me and to the teacher of Home Economics who furnished the samples. One pupil was interested in testing bisodol. She looked up the usual tests for carbonates. She compared the weight change when the bisodol is heated with the weight change of sodium bicarbonate when it is heated. She found that carbon dioxide was given off during the heating process. She looked up tests for certain metals and confirmed the presence of bismuth in this widely advertised remedy. No attempt is made in this type of work to make complete analysis of anything that comes along, because high school pupils are not able to do that, as you well know. An attempt is made to limit the pupil's investigation to a job that is not so difficult, but that he may complete it with some profit to himself. These projects are all done outside of the regular class and laboratory time, during study periods and sometimes after school and in no way are a substitute for any part of the work except as mentioned before, the paper which might have been based upon outside reading.

These projects are begun by the pupil only after conference with the instructor and after fairly definite plans have been made as how to go about the work. It is most important that the pupil be confined at the beginning to a less ambitious under-

taking and then let it grow, if one is fortunate, into a larger investigation rather than to start with too large an undertaking and have the pupil become overwhelmed with it later. For example, the special tests in soap were limited to testing the soaps for free alkali and for alkali in the filler. These two tests can be made rather simply and no further complicated analysis was undertaken. Another project that proved of interest and on several occasions grew after a small start, was the testing of soils for alkalinity and acidity. Pupils interested brought samples of dirt from their yards to school and tested them with litmus paper. Those who cared to go on took samples from their yard at regular intervals, according to a small plot which they drew, and tested these samples with soiltex (containing bromthymol blue as indicator), a commercial indicator by which one is able to estimate the amount of limestone needed per square rod (by comparing the color of the indicator with a color chart prepared by a chemist of Albert Dickenson Company) to grow clover or blue grass. A word about some other projects. Two boys tried to determine the relative bleaching power of two well known and widely advertised bleaches of the chlorine type by titration. The work on household ammonia consisted of titrating for total alkalinity and a sediment test. In comparing water softeners, measured amounts of three softeners were added one each to a gallon of water and the softening effects determined by titration with soap solution. The ideal amount of each softener was determined and relative costs calculated. Then there were the usual preparations of cold cream, tooth paste and tooth powder, and of testing commercial tooth powders for grit as outlined in the "Consumer's Guide." There were, of course, other pupils who contented themselves with reading from whatever sources they could find, discussions and recommendations of the Pure Food and Drug Act and their application to certain products in which they were interested.

The question will naturally arise in the minds of some of you: "What is the difference between this so-called consumer chemistry and ordinary household chemistry?" I have been asked that question and consider it a fair question. To me the answer is just this: "We are not so much interested here in finding out how some household process takes place, but we are more interested in finding out ways of testing consumer products so that the buyer may know something of the nature of the goods that he is buying." I shall have more to say of that later. An-

other question that might properly come to mind is: "What is the purpose of this extra work?" And I shall try to answer that very simply without using complicated technical educational terms. In the first place, quite a number of pupils are interested in this sort of thing and that interest leads them to some study; to apply some information that they would otherwise neither learn nor apply. In the second place, it helps to develop a sense of consumer interest in the pupil. We, as chemists, know that when a large company buys coal, it buys it according to specifications, not according to the influence of high-pressure salesmen or other descriptive terms which really mean nothing. The commercial buyer of coal wants to know how much water there is in the coal, how much volatile matter, and how much ash; and knowing these things he can tell how much the coal is worth to him. It doesn't take the pupil very long to appreciate the fact that he and his family might use technical knowledge to determine quality and fitness of a great many consumer goods from coal to cloth and from tooth paste to baking powder. In other words, the pupil becomes conscious of a way in which chemistry can be put to very valuable everyday use. Furthermore, no pupil, at least in Austin, is misled to believe that he, having taken only high school chemistry, is competent to act as an analyst and tester of any and all products that he might want to buy. I think the point might be illustrated in this way: while teaching at Austin I went through evening law school, and the most important thing I learned there was that when some legal investigation needed to be carried on that a lawyer and not an amateur should do it. I believe these pupils, in a similar way, learn that there are ways of making these tests properly and they learn how to do some of it, but they also learn that a reliable analyst of some sort is needed to do most of that work. When enough of our graduates from high school reach that point, such agencies either formed by commerce itself or by groups of consumers, will rise to meet that need.

How many times we have said, "But still we buy food that gives neither a balanced diet nor a balanced budget. We still buy cotton and pay for wool; we still buy rayon and pay for silk; we still buy autos that use too much gas, patent medicines that do not cure, and books that are not worth reading."[1] "Schools have not taught our population to live effective eco-

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[1] *Department of Secondary School Principals*, January, 1938, page 23; R. W. Walters, Grove City, College.

nomic lives. Day by day the great mass of people are blundering in their daily habits of consumption. Unwittingly they reject beauty, health, and comfort. They suffer tremendous waste of food and fuel. With an adequate income, they are ignorant of the most economic habits of purchase of food and fuel. Economic life makes a fundamental demand which education will increasingly meet in order to "restore the well doing of every thing that needs to be done."[2]

From *Consumer Protection, How It Can Be Secured*, by Roger W. Babson and C. N. Stone, Harper & Brothers, New York, $2.50, we read:

> It is not surprising that the consumer today gets so little for his dollar. The wonder is that he gets as much as he does. Think it over for a few minutes. Many large interests are arrayed against you. The manufacturers are able to employ the ablest men—from chemists to psychologists—to fool you. The merchants can employ the ablest literary and artistic brains to prepare advertisements to mislead you. The publishers of newspapers and magazines, whose income depends upon these advertisements, are almost forced to shade their news column to aid the seller of the goods rather than the buyer. This applies even to your small investments in case you have a dollar left over after all the various vultures have had a turn at you. Railroads, lawyers, doctors and candlestick makers all seem combined to milk you.
>
> The present profit system may be facing a death sentence unless something is done for the consumer. The men and women of America will not forever tolerate such economic practices as destroying livestock, plowing under cotton, dumping milk in the gutter, burning grain, and systematically operating the industrial plant below its full capacity . . .
>
> Labor division, machinery, power and other technical progress have demolished the old economy of scarcity. Consumers are demanding in its place the creation of an economy of abundance. . . . All that an economy of abundance implies is the operation of the economic plant at normal capacity and the continuous expansion of that plant with continuous invention and discovery. Consumers do not ask for Utopia. All they require is the elimination of sabotage in all its forms.

It is to help the pupil help himself in later life to overcome this very unsatisfactory set of circumstances that we have undertaken the teaching of chemistry from the consumer's point of view.

The main point of this teaching then will not be to acquaint the pupils with any particular brand of recommended or unrecommended products on the market, but rather to acquaint them with the general problem as stated above and to introduce them to a scientific method of solving it. Such a method has been used in a number of cities and towns in the United States. For example, the high school at Hiram, Ohio, has introduced

[2] *J.N.E.A.*, October, 1936, page 213.

a course of consumer problems which is taught in the commercial department. The objects, of which there are many, revolve around the one idea of teaching consumers how to buy intelligently; how to recognize standards, and to counteract undesirable salesmanship. At Hiram, a student investigator found that trombone oil was being bought by the pupils in the band in small bottles at a rate of thirty-six dollars a gallon. After this investigation the band ordered the oil by the gallon at sixty cents a gallon plus delivery charges. At Elmhurst, Long Island, a course entitled "Teaching the Characteristics of Consumer Goods" has been taught for over two years. That course is taught in the Home Economics Department in cooperation with the chemistry department. The most vital problem that has faced them has not been opposition from merchants or sales people in the community, but the problem of presenting such a variety of subjects on the pupil's level of ability. In general, their activities are listed under four heads: the making of scrapbooks, laboratory projects something like those done at Austin, bulletin board exhibits, oral and written reports.

We often hear it said that manufacturers and retailers claim that the competition they have to meet is based upon style and price rather than quality and so have emphasized the first two, thinking that these are what the consumer wants. Have they misunderstood us or do we show by our buying habits that they are correct? Everywhere it seems apparent that these courses in consumer problems are trying to help young people form buying habits based upon scientific information that will help them make their income go farther and the products purchased serve better.

Every now and then some organization sets itself up to educate the public to use the particular product of that organization and so we have "milk weeks," "wool weeks," etc. Some organizations set up testing laboratories which are more or less window dressing and are usually supported by funds from the budget of the advertising department. As a student becomes conscious of consumer interests, such devices as these will affect him less and less.

In addition to Hiram, Ohio, and Elmhurst, Long Island, the Libby High School at Libby, Montana, and a number of schools in California have definite courses of study based upon consumer problems. In 1937 a questionnaire was sent out to all the high school principals in California. One hundred and ninety six

principals reported that their high schools had consumer courses in the curriculum. The total number of pupils enrolled in these courses was one thousand three hundred forty-two, and in addition forty-seven elementary schools in California reported some consumer work was being done.

In conclusion let me say that this teaching of consumer chemistry gives the pupil some practice in problem solving, and the techniques that are best adapted to solution of problems within the field of chemistry, especially those which most often present themselves in daily life. This means the development and use of the scientific method by the pupil. Furthermore, this work from the point of view of the consumer will help the pupil develop those attitudes toward ways and methods of investigation which will aid in developing a definite consumer consciousness and therefore help shape his economic life more to his satisfaction.

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ATTITUDES RELATED TO THE STUDY OF COLLEGE SCIENCE

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If the state of development of tests evaluating attitudes, opinions, etc., were advanced to that of those testing factual information, I might have entitled this paper, "Attitudes Produced by the Study of College Science Courses," but that condition is remote and is a development that remains for the future. We have for a long time been able to measure achievement in factual information with a degree of accuracy, but little attempt has been made to measure other changes which may take place in our students: changes in attitudes, appreciations, interests, and opinions.

Some of the leaders in the field of education today tell us that facts are not important; that they are soon forgotten; that it is the other things which are acquired along with the facts which we remember from our high school and college courses. Perhaps no one wholly agrees with such a philosophy, but most would agree that both are important. It might seem that they are closely related, but do we know we are making the kind of growth in these attitudes, opinions, interests, etc., which we set forth in the aims of our science courses?

Where do we get out attitudes? Does the study of science courses produce a scientific attitude? Does the study of courses in social science produce social attitudes? Does the study of any field of subject matter produce attitudes peculiar to the field? Perhaps we would like to answer such a question in the affirmative, but are we justified in doing so when we consider the development of tests which might be expected to evaluate growth in these attitudes? It might be possible however, if an accurate inventory were made of the attitudes of a group at their entry in college, and again at the close of their college

course. All such changes and growth in attitudes would be revealed. In the study here reported, only one evaluation was possible and that was at the close of the college study.

The differences found in the attitudes of the groups studied seem to be related to the study of college science courses. They may be causal or they may be the result, by analysis of the data one can interpret to some extent which relationship exists.

In attempting an analysis of such groups, two ways appear somewhat feasible. The maker of the test might from a review of all available material, study all the attitudes which are expressed as goals in the many science courses and by analysis of these expressions make a list of items which would evaluate the attitudes of the subject or the group being studied. Such a method assumes that the goals set up for our courses are being achieved. The other possible attack to the question is to use an extremely large number of items, so varied in nature that not only the suspected attitudes will be evaluated, but also many unsuspected ones. The second method has the advantages of the first and offers a promise of some possible surprises.

The instrument which forms the basis of this experiment is the fifty-four page "Attitude Finder" known as the "Youth Expressionaire" developed in the Character Education Institute at Washington University, St. Louis, Mo. This instrument consisting of some three thousand items and requiring about seven hours of the subject's time, has been reacted to by approximately one thousand persons, chiefly young people between the ages of eighteen and thirty, all high school graduates or better. The reactions to the Expressionaire have been transferred to Holerith cards and are available for rapid sorting and counting on the basis of numerous and varied groupings, making wholesale statistical analysis feasible.

In this study only two hundred and fifty of the subjects were used. One hundred and fifty college graduates and one hundred high school graduates of the same approximate age. Out of the college graduates two groups were formed, herein after referred to as the Science group and the non-Science group. The Science group consists of the fifty college graduates who apparently have studied mostly in the field of science, and the non-Science group consists of the fifty college graduates who have studied least in this field. The one hundred high school graduates are referred to as the non-College group. The college groups were equated for sex, age, and race and were found to

differ only slightly in intellect, economic background and political outlook.

The percentage response was determined for each of the reactions made possible by the test. This per cent represents that part of the group who by their marking of the Expressionaire agree with the item. The percentage score of the Science group was contrasted with the scores of each of the other groups. For example, we may consider the item, "Cleanliness is a more valuable trait than curiosity"; 28% of the Science group agree with the item, 64% of the non-Science group agree, while agreement in the non-College group is 74% of the group. The chief interest of this study is in the college groups; this third score is a base which we may assume that some of the growth has been made. Only the two hundred and seventy-six items in the Expressionaire on which the percentage scores of the college groups differ by as much as 20% (3 sigma) of the groups were considered statistically significant. The analyses of the attitudes were made by grouping these significant items, which by their obvious nature express similar attitudes.

The wholesale net effect of the Expressionaire brought forth some unsuspected results along with those that might be reason-

TABLE I

TRAIT AND ATTITUDE DIFFERENCES REVEALED BY THE EXPRESSIONAIRE

Attitude or trait	*Number of items having 20% or more difference*	*Average item score for traits studied*		
		NC	*S*	*NS*
Pacifism	12	52.0	71.5	49.7
International Mindedness	18	53.0	75.0	49.0
Social Mindedness	5	53.6	68.8	41.6
Prejudice	13	44.5	21.0	46.3
Religion	6	57.1	34.5	57.2
Hopeful Outlook	7	56.4	72.5	46.0
Conservatism	All items, Form J, C-R Opinionnaire[1]	52.2	28.6	39.6
Vocational Likes	45	32.4	45.9	21.9
Vocational Dislikes	48	41.4	24.4	55.2
Activity Likes	40	46.0	58.5	33.5
Activity Dislikes	13	40.2	27.0	50.4
Food Likes	10	50.6	65.8	43.2
Food Dislikes	3	53.6	29.3	54.0

(NC% of non-College group expressing the trait or attitude)
(S% of Science group expressing the trait or attitude)
(NS% of non-Science group expressing the trait or attitude)

[1] Lentz, Theo. F. Jr., and Colleagues, *C-R Opinionnaire, Form J* (Washington University, St. Louis Character Research Institute, 1935).

ably expected. Some attitudes were noticeably absent. In the following table will be found a listing of some of the attitudes expressed and the item score (average of all the items expressing an attitude), for each of the three groups.

In the first attitude listed, that of pacifism, we find that twelve items seem to express this attitude. When all these items are considered the Science group express a pacifistic attitude 71.5% of their reactions, while 49.7% of the non-Science group express such an attitude. The non-College group fall between the other two groups with a score of 52% of the group. An item that well expresses the feeling of pacifism, "When our country is at war, it is our duty to support it, whether or not we are in sympathy," was agreed to by 66% of the non-College group, 60% of the non-Science group and only 32% of the Science group. Their pacifism scores are: 34%, 40%, and 68% respectively. This appears to be a surprise twist and it may be a rather difficult one to understand; how a nation with the scientific background of Germany can have such a non-pacifistic attitude.

An item that well expresses the attitude toward religion and is typical of that group, is found in, "All children should have some sectarian religious training, either on Sunday or on week-days." The non-College group is most conservative with a score of 85% agreeing; next is found the non-Science group with a score of 80% while only 56% of the Science group agree with the item.

A more hopeful outlook is displayed by the Science group and this is represented in such an item as "There is a satisfactory solution to the problem of excessive drinking." The Science group agree 78%, the non-Science 42%, and the non-College group 42%.

An unusual finding was noticed in grouping the items that represent a particular attitude, never is there an item score in which the two college groups seem to be reversed; that is, in every item that expresses a more hopeful outlook, the Science group is always more hopeful and the non-Science group less hopeful or, if we consider the religious items, the non-Science group is always more conservative and the Science group less so.

The likes and dislikes for activities, vocations, foods, authors, books, etc., revealed some of the greatest differences between the groups. The Science group always expresses a greater number of likes and the non-Science group expresses greater dis-

like, with the score of the non-College group always found between the scores of the college groups. In more than 50% of the item scores, the non-College group were found between those of the college groups and always nearer the score of the non-Science group. Findings such as these may indicate "cause" for the study of science courses rather than "results" of such study, or that any growth in these attitudes that are produced in college, the study of science courses produce more of such growth, at least in as far as this study reveals their attitudes.

The study does not reveal any differences in superstitious beliefs or any items that show differences of factual scientific information. These items were noticeably absent from the list of items showing significant differences. The Science group were more accurate in scoring the Expressionnaire. Other so-called scientific attitudes such as suspended judgment were not revealed because of the nature of the testing device.

A list of seventy-six items showed the same percentage agreement in the college groups, of these a large number of the items involved the matter of one's ability to evaluate himself or his abilities and it seems that neither college training nor the study of college science courses have much effect on this ability.

A list of the most differentiating items found in the Expressionnaire for the two college groups has been used to investigate other groups. This list consists of two hundred and twenty-six items, a much shorter list, but one that does reveal some of the differences that are found between those who have studied college science courses and those who have not. When given to a group consisting mostly of teachers, in a study made by Miss Wanda Gum, Miss Stella Gaebler, and Miss Doris Buhrle, graduate students of Washington University, it was found that those teachers who had studied largely in the field of science reacted much the same as the Science group, while the remainder reacted much like the non-Science group.

In a study made by Miss Harriet L. Brent, graduate student at Washington University, these two hundred and twenty-six items were also given to seven hundred and fifty high school seniors in their eighth semester. From this group were selected seventy-five pupils who had studied six or eight semesters of high school science. They were contrasted with seventy-five seniors who had had only one or two semesters of science training. The only differences found in the high school groups were their dislikes for activities, vocations, foods, etc. The social

attitudes were as nearly identical as it would be possible for them to be, at least as the items of the test reveal them.

Summary and Conclusions

The wholesale net effect of the Expressionnaire made it possible to discover many suspected and unsuspected differences between the groups. These differences, along with other findings of the investigation, are summarized in the following conclusions:

1. Those who have studied more science do have different attitudes, opinions, and interests.
2. The opinions and interests of the non-Science group are more like those of the non-College than they are like those of the Science group.
3. The Science group has a greater respect for accuracy.
4. There is no significant difference in superstition between the college groups. The non-College group is more superstitious.
5. 5. The Science group is more openminded and has less prejudice.
6. The Science group is more pacifistic. However college training seems to be associated with a more pacifistic attitude.
7. The Science group is more internationally-minded and expresses a friendlier feeling toward other people of the world.
8. The Science group expresses a greater preference for work in the various vocations and professions.
9. The Science group is more tolerant, as shown by the lesser number of dislikes of foods, activities, vocations, etc.
10. The Science group is more liberal in views toward religion.
11. The non-Science group is more conservative but not as conservative as the non-College group.
12. Persons of all three groups react about the same to items concerning estimations of themselves of their abilities.
13. We cannot be sure which of these differences caused the science group to select their vocations and which are the result of their training in the field of science.
14. Analysis of the data might lead one to believe that some differences are the "cause" of the science study, while other differences are the "effect" of such study.

THE PLIGHT OF HIGH SCHOOL PHYSICS

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All is not well with high school physics. Steady decline in the percentage of students enrolled in the subject, the bad odor which its name enjoys with many parents and students, the unyielding character of the resistance offered by vested interests, of whatever the kind, to any real change in the subject matter or laboratory procedures—all these and other bits of evidence bespeak a subject with which things most certainly are not well.

Little is needed in the way of proof of these assertions. Enrollment figures are readily available. The two graphs, drawn from figures for the years 1890, 1895, 1900, 1905, 1910, 1915, 1922, 1928 and 1934, as reported in a recent government publication tell the tale well. In the last year reported, the enrollment though actually increasing (Fig. 1) was doing so at a rate far slower than that at which the high schools are growing. A smaller and smaller percentage of high school students elect the subject (Fig. 2). Of course, the existence of extenuating circumstances to explain this decrease may be considered. However, it should be borne in mind that one of the most cogent of these, i.e., the increased diversity of the high school offering of subjects, applies with equal force to most subjects, few of which have suffered the proportionate losses that physics has had.

A comparison of the physics texts used in 1879, shortly after the subject had replaced earlier Natural Philosophy courses, with modern texts, reveals how little has been the change in subject matter and organization in the span of 60 years. We have tinkered with the subject, introducing new material here and dropping some minuscule bit of subject-matter there, but that is all. In 1886, there appeared the *Harvard Descriptive List* of experiments, 40 in all, which were to be performed by high school students. These, too, have survived the ravages of time with surprising ease as a number of recent investigations have shown. What a contrast between this immutability and the flashing chiaroscuro of change in science, itself, and in economic and social life!

These paragraphs, abbreviated though they may be for the purpose, are intended as an introduction to, and justification

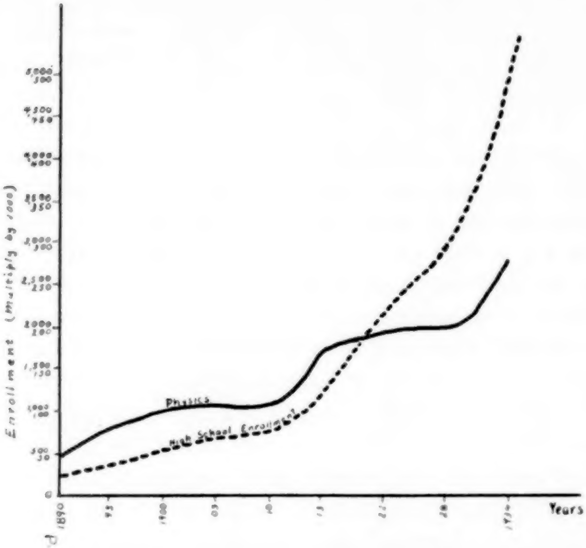

FIG. 1. Enrollment in physics as compared with total high school enrollment (1890–1934). Each of the figures along the ordinate are to be multiplied by 1,000. The upper figures apply to the total H. S. enrollment, the lower to physics enrollment. Figures are for the last four years of the secondary school and are taken from the Office of Education Bulletin 1938, No. 6 "Offerings and Registrations in High School Subjects."

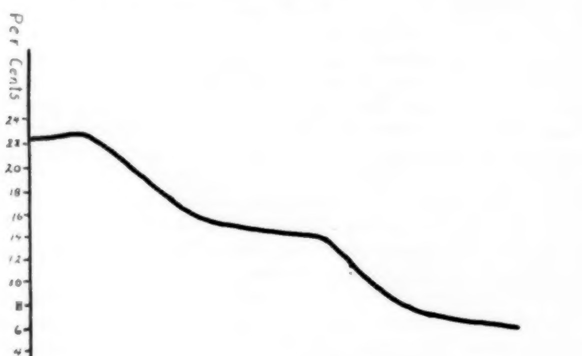

FIG. 2. Percentage enrollment of high school students enrolled in physics courses. Figures are for the last four years of the secondary school and are taken from the Office of Education Bulletin 1938, No. 6, "Offerings and Registrations in High School Subjects." Since 1910 the percentages are based upon the number of students in the schools reporting the various subjects rather than upon all students known to be in high school, as was the case before 1910.

for, a series of short articles in each of which I shall attempt to discuss one factor which, in my opinion, contributes to the general debility of the subject. In each, lest I be charged with mere negativism, I shall make suggestions as to how, in my opinion the fault may be eliminated or rendered less morbific.

And now let me anticipate a possible reaction on the part of the reader. You may feel that if things are as badly off with physics as has been indicated, perhaps the best thing to do would be kill it off as a separate subject, using whatever of its content we may desire in new integrations of subject matter. And indeed in a certain few situations, where conditions are ripe for change, this may be the answer. The establishment of integrated courses in the physical sciences, designed to replace separate courses in physics and chemistry, in a few schools does this very thing. And yet I am convinced that, for the great majority of schools and for the great majority of science teachers, any attempt to introduce such courses on other than a limited and experimental basis would be calamitous. So to do would retard rather than advance the cause of the reorganization of the science offerings on the high school level. Reasons for this assertion derive from the following considerations:

1. A great deal of the subject-matter from the field of physics is socially important. It is important for the high school student to understand the meaning of such terms as *power*, *work*, *energy;* to know what it is that a machine does for us; to understand the effects of noise on the nervous system; to gain both understanding and appreciation of the flow of energy throughout the universe and of man's use and control of that energy.

2. In spite of what has been said about the declining enrollment in physics, there is still a large group of students who take the subject, and a large group of schools that offer it. In 1934, the total enrollment in physics in the United States was reported to be about 282,000. About 8,600 schools offered the subject—a number of schools larger by about 2,000 than of those offering chemistry, although there were about 60,000 more students in the latter subject. Such a school offering in physics cannot be uprooted over night without doing profound harm.

3. Things move slowly in educational circles. The college entrance situation, bad though it is in many ways, will be perpetuated with little or no significant change for many years. Furthermore, I am extremely skeptical of any real liberalization of the college entrance requirements growing out of the so-called 30-School Experiment.

4. Things move slowly in educational circles. Very few teachers are willing, or if willing, are able, to make sweeping changes in their science offerings within a short period of time. To require them to make such changes would produce feelings of insecurity, reactions against which would result in defense procedures which could not but have unfortunate effects upon both children and the hope of revision. It is for this reason that "boring from within" the framework of subjects already in existence is likely to be more productive of desirable results than experimenting with new subjects.

5. Parents of intellectually able children, as well as the parents of many children who are not so able, are likely to demand that their children take subjects which are acceptable for college entrance credit. Around such subjects, of which physics is one, a specious prestige is enhaloed. For this reason, all too often the success of educational experiments with new courses is prejudiced, since the better students are not included.

It is for reasons such as these that I am interested in seeing what can be done to improve a subject already in existence. It is hoped that the subsequent articles in this series may be of help in that connection.

THE LEHMUS-STEINER THEOREM

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History

In 1840 Professor Lehmus sent the following theorem to Jacob Steiner with a request for a purely geometric proof:

If the bisectors of the angles at the base of a triangle, measured from the vertices to the opposite sides, are equal, the triangle is isosceles.

Steiner complied in 1840 but it was not until 1844 that his proof was published in the *Journal für die reine u. angewandte Mathematik*, vol. 28, p. 375.[1]

After proving the theorem when two internal angle bisectors are equal, Steiner observed that the hypothesis is not as simple as one might believe at a first glance; for the phrase, "bisectors of the angles at the base," is equally applicable to the exterior or interior angles. He then considered the cases when the feet of the two external angle bisectors are (a) both above the base or both below the base, (b) on opposite sides of the base, and (c) when the internal bisector from one end of the base equals the external bisector from the other end. He proved that for (a) the triangle is always isosceles, pointed out that for (b) it is not isosceles and that for (c), although the triangle in general is not isosceles, it may be isosceles for triangles of a special species. Finally, he generalized the theorem and discussed the theorem for the spherical triangle.

From 1844 to 1855 some fourteen proofs were given in Grunert's *Archiv der Mathematik u. Physik*.

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[1] Also Steiner's *Gesammelte Werke*, vol. 2, p. 223

The theorem was the first question proposed in *Nouvelles Annales de Mathématiques,* vol. 1, 1842, p. 57, and geometric proofs were given in the same volume by Rougevin, p. 138, and H. Grout de Saint Parr, p. 311. In the same volume, pp. 79–87. the theorem was considered by O. Terquem.

In England, the theorem appeared at the University of Cambridge about 1851, according to J. J. Sylvester in the *London, Edinburgh and Dublin Philosophical Magazine,* 4th Series, vol. 4, 1852, pp. 366–369. He also remarked that its solution is "by no means so obvious and self-evident as one would expect from the extreme simplicity of its enunciation." He reproduced an indirect proof by B. L. Smith, gave an independent proof of his own, and, after some analytical discussion, he advanced the conjecture that the proof of this theorem must necessarily be indirect. As an example, he requested a direct proof of the following theorem: "If from the middle of a circular arc two chords be drawn, and the remote segments of the chords, cut off by the line joining the ends of the arc, are equal, the nearer segments will also be equal. "A direct proof was given by Thomas K. Abbott in vol. 5, 1853, pp. 286–287.[2]

Twenty-two years later, N. M. Ferrers of Cambridge University forwarded to the editors of the *Philosophical Magazine,* 4th Series, vol. 47, 1874, pp. 354–357, a proof which appears to be the first direct proof using no theorem beyond the first book of plane geometry as given in an elementary text such as Wentworth's *Plane Geometry.* It had been sent to the Vice-Chancellor of Cambridge by Christine Chart of California, who stated that the proof, dated 1842, had been discovered by F. G. Hesse.

The only other direct proofs, based on Book 1, that we have found, are by G. I. Hopkins[3] in his *Inductive Plane Geometry,* rev. ed., 1902, p. 29, and W. W. of Amsterdam in *Zeitschrift für math. u. natur. Unterricht,* vol. 44, 1913, p. 557.

We have noted that Jacob Steiner was the first to make known the scalene triangle having two external angle bisectors equal, although analogy with the altitudes, medians, symmedians[4] and the internal angle bisectors tends to deny its

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[2] See also vol. 5, pp. 297, 332, 405; *The Lady's and Gentleman's Diary,* 1860, p. 84.

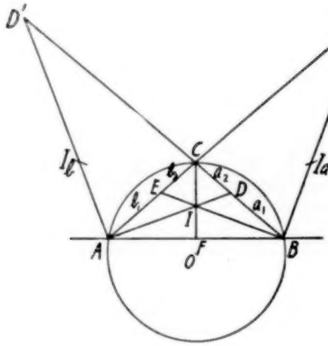
[3] See also *Amer. Math. Mo.,* vol. 9, 1902, p. 43; Elisha S. Loomis, *Original Investigation,* no date, p. 11. The direct proof on p. 11 of the 1901 edition, whose eighth step is false, was later replaced by Hopkin's proof.

[4] *L'Intermédiaire des Mathématiciens,* vol. 1, 1894, p. 50; vol. 2, 1895, pp. 151, 325.

existence. Such triangles are called pseudo-isosceles triangles,[5] a term suggested by J. Neuberg.[6] Although Marcolonga had asked in *Mathesis*, 1884, p. 200, whether a spherical triangle can have two medians equal without being isosceles and Dr. Krüger had given in the *Zeitschrift für math. u. natur. Unterricht*, vol. 24, 1893, p. 439, the condition that an internal angle bisector equal an external, yet it was not until 1894 that the attention of geometers was directed to these triangles by the request of Alauda for a proof of the relation $a^2+bc=4Rr_a$.[7]

The question was taken up by *Mathesis*, 2nd Series, vol. 4, 1894, p. 152, and a proof was given by Soons in vol. 5, 1895, p. 261. The same year A. Emmerich proposed and answered the question[8] "Must a triangle be isosceles, if two external angle bisectors are equal?" From 1894–1907 the properties of this triangle were studied by Emmerich, Fontené, Cristesco, and Marx.

We now give some proofs of the first case, when two internal angle bisectors are equal, classified under the headings Book I, Book II, etc., according as they involve no theorem beyond Book I, Book II, etc. as given in a textbook on plane geometry such as Wentworth's 1899 edition.



Symbols.—In triangle ABC we designate the sides BC, AC, AB by a, b, c; the perimeter and area by $2s$ and Δ respectively; the internal angle bisectors AD, BE, CF by t_a, t_b, t_c; the external angle bisectors AD', BE', CF' by t_a', t_b', t_c'; the center and radius

[5] The term has been extended to include scalene triangles having any two elements equal which are of the same speces as those whose equality in the isosceles triangle is due to the axis of symmetry.—*Mathesis*, 3rd Series, vol. 7, 1907, p. 184.

[6] *Mathesis*, 2nd Series, vol. 10, 1900, p. 129.

[7] *L'Intermédiaire des Mathématiciens*, vol. 1, 1894, p. 70.

[8] *Zeitschrift für math. u. natur. Unterricht*, vol. 25, 1894, pp. 116, 583.

of the circumcircle by O and R; the centers and radii of the tritangent circles by I, I_a, I_b, I_c, and r, r_a, r_b, r_c; and the segments BD, DC, AE, EC by a_1, a_2, b_1, b_2 respectively.

PROOFS BASED ON THE ANGLE-BISECTOR FORMULA

1. By this formula we have

$$\frac{bc(a+b+c)(-a+b+c)}{(b+c)^2}=t_a^2=t_b^2=\frac{ac(a+b+c)(a-b+c)}{(a+c)^2}$$

whence
$$\frac{c}{a-b}=\frac{ab(a+b)+4abc+c^2(a+b)}{ab(a-b)-c^2(a-b)}$$

$$a-b=0 \quad \text{and} \quad c^3+c^2(a+b)+3abc+ab(a+b)=0.$$

Hence $a=b$ and as the second equation has only positive terms, it cannot give us a triangle whose sides fulfill the condition.[9]

2. A trigonometric solution may be obtained by using $\triangle BAD=\frac{1}{2}\, ct_a \sin\frac{1}{2}A$, $\triangle CAD=\frac{1}{2}bt_a \sin\frac{1}{2}A$, whence $\frac{1}{2}ct_a(b+c)\sin\frac{1}{2}A=\triangle ABC=\frac{1}{2}\, bc\sin A=bc\sin\frac{1}{2}A\cos\frac{1}{2}A$. Hence $t_a=(2bc\cos\frac{1}{2}A)/(b+c)$ and in like manner $t_a=(2ac\cos\frac{1}{2}B)/(a+c)$.[10] If $t_a=t_b$, $\cos\frac{1}{2}A/\cos\frac{1}{2}B=a(b+c)/b(a+c)$ and if $a\neq b$, say $a>b$, the left member is <1 and the right member is >1, which is impossible. Hence $a=b$.

3. R. Wolf, *Archiv. der Math. u. Physik*, vol. 3, 1843, p. 445.[11]

By using
$$bc=\frac{a^2bc}{(b+c)^2}+t_a^2,\qquad ac=\frac{ab^2c}{(a+c)^2}+t_b^2,$$

we have
$$b—a=\left[\frac{a}{(b+c)^2}-\frac{b}{(a+c)^2}\right]ab.\qquad \text{If}\quad b\gtrless a,$$

$$b-a\gtrless 0,\qquad b+c\gtrless a+c,\qquad a/(b+c)\lesseqgtr b/(a+c)$$

and we have a positive quantity equal to a negative quantity which is impossible.

4. L. Mossbruger, *Archiv der Math. u. Physik*, vol. 4, 1844, p. 331.[12] Using $ca_2=a_1(b_1+b_2)$ and $cb_2=b_1(a_1+a_2)$ with $bc-a_1a_2=t_a^2=t_b^2=ac-b_1b_2$, we have $cb_1+b_1(a_1+a_2)-a_1a_2=ca_1+a_1(b_1+b_2)-b_1b_2$, whence $b_1=a_1$, $\triangle ADB\cong\triangle AEB$, $\angle A=\angle B$.

5. E. Lavelaine, *Nouvelles Annales de Mathématiques*, vol. 13, 1854, p. 192.[13]

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[9] Similar proofs are given in *Archiv der Math. u. Physik*, vol. 4, 1844, p. 330; vol. 15, 1850, pp. 225–226; vol. 37, 1861, p. 457; *The Lady's and Gentleman's Diary*, 1857, p. 59; *Periodico di Matematica*, vol. 7, 1892, p. 150.

[10] A solution by Dickson in *Amer. Math. Mo.*, vol. 9, 1902, p. 43, utilizes this formula to obtain the equation

$$s(s-a)bc/(b+c)=s(s-b)ac/(a+c).$$

[11] Essentially the same proof was given in *Archiv der Math. u. Physik*, vol. 13, 1849, p. 324; *Journal de Mathématiques Elémentaires*, vol. 9, 1885, p. 130; *Zeitschrift für math. u. natur. Unterricht*, vol. 24 1893, p. 438; *Supplemento al Periodico di Matematica*, 1899, p. 69; *Math. Questions from the Educational Times*, voi. 74, 1901, pp. 73, 106.

[12] Same proof was given in *Amer. Math. Mo.* by Heal who stated it was given to him by Artemas Ward.

[13] The same proof was given in *Periodico di Matematica*, vol. 7, 1892, pp. 187–188; *Amer. Math. Mo.*, vol. 2, 1895, p. 190, with fallacious reasoning,—see vol. 7, 1900, p. 226; *The Lady's and Gentleman's Diary*, 1860, p. 85. Another proof in *Nouvelles Annales de Mathématiques*, vol. 13, p. 192 is inexact. See vol. 14, 1855, p. 32.

Using $a_1 = ac/(b+c)$, $b_1 = bc/(a+c)$, we have, if $b \gtrless a$, $bc \gtrless ac$, $b+c \gtrless a+c$ and $b_1 \gtrless a_1$. Likewise, $b_2 \gtrless a_2$ and from $bc - a_1a_2 = t_a^2$ and $ac - b_1b_2 = t_b^2$, we have $t_a \gtrless t_b$, which is impossible.

The proof given by Richard Jones in *The Schoolmaster*, July 13, 1878, is a variant of Lavelaine's proof. Assuming $b > a$, we have $\angle CBI = \angle ABE > \angle CAI = \angle BAD$ and $b_1 > a_1$. By drawing IG to cut AC at G so that $\angle CIG = \angle CID$, and CI, then $\angle CIE = \frac{1}{2}\angle C + \angle CBI > \frac{1}{2}\angle C + \angle CAI = \angle CID$ and $b_2 > CG = a_2$, since $\triangle CIG \cong \triangle CID$. Hence, as before, $t_a > t_b$, which is impossible.

6. Ch. Nagel, *Archiv der Math. u. Physik*, vol. 20, 1853, p. 470.

Prolonging AD and BE to cut circle ABC at G and H, and setting $DG = m$, $EH = n$, then $\triangle ADC \sim \triangle ABG \sim \triangle BDG$, $bc = t_a(t_a + m)$, $BG^2 = m(t_a + m)$. In like manner, $ac = t_b(t_b + n)$, $AH^2 = n(t_b + n)$.

If $n \neq m$, say $n > m$, we are led to a contradiction; for, then, $ac = t_b(t_b + n) > t_a(t_a + m) = bc$ and $a > b$ while $BG^2 = m(t_a + m) < n(t_b + n) = AH^2$ and $a < b$. Hence $m = n$, $BG = AH$ and $a = b$.

7. L. Meurice, *Mathesis*, 2nd. Series, Vol. 4, 1894, p. 92.

In any triangle ABC take $BH = AB$ on CB prolonged and on CB take $CG = AC$. Since the bisectors of angles C and ABH are perpendicular bisectors of AG and AH respectively, I_c is the center of circle AGH which is tangent to AD at A.

Now $ca_2 = ba_1$ and $t_a^2 = bc - a_1a_2 = bc - a_1a_2 + ca_2 - ba_1 = (c - a_1)(b + a_2)$ and since $t_a^2 = DH \cdot DG = (c + a_1)(b - a_2)$, we have $(c + a_1)(b - a_2) = (c - a_1)(b + a_2) = t_a^2$. In like manner, $(c + b_1)(a - b_2) = (c - b_1)(a + b_2) = t_b^2$.

When $t_a = t_b$, $(c - b_1)(a + b_2) = (c - a_1)(b + a_2)$ or $(c - b_1)/(c - a_1) = (b + a_2)/(a + b_2) = (c - b_1 + b + a_2)/(c - a_1 + a + b_2) = (c + b_2 + a_2)/(c + a_2 + b_2) = 1$.

Hence $AE = BD$, $\triangle ABE \cong \triangle ABD$ and $\angle A = \angle B$.

Other proofs based on the angle-bisector formula were given by J. Grunert, *Archiv der Math. u. Physik*, vol. 42, 1864, pp. 233–235; S. Günther, *Zeitschrift für math. u. natur. Unterricht*, vol. 23, 1892, p. 579—see also same periodical vol. 24, 1893, p. 439—and A. Lugli, *Periodico di Matematica*, vol. 7, 1892, p. 149.

Direct Geometric Proofs Based on Book I

1. F. G. Hesse, *London, Edinburgh and Dublin Philosophical Magazine*, 4th Series, vol. 47, 1874, p. 354.[14]

Construct the quadrilateral $ABDG$ so that $AG = AE$, $DG = AB$. Then $\triangle ADG \cong \triangle ABE$, $\angle AEB = \angle GAD$, $\angle ADG = \angle ABE$. Also $\angle AEB + \frac{1}{2}\angle A = \angle DIE = \angle BDA + \frac{1}{2}\angle B$. Hence, $\angle GAD + \frac{1}{2}\angle A = \angle BDA + \angle ADG$ or $\angle GAB = \angle BDG = \angle DIE$.

But $\angle DIE = 180° - \frac{1}{2}(\angle A + \angle B)$ and $\angle A + \angle B < 180°$. Hence $\angle GAB = \angle BDG = \angle DIE > 90°$ and $\triangle GAB \cong \triangle BDG$.[15] Hence $BD = AG = AE$, $\triangle ABD \cong \triangle ABE$ and $\angle A = \angle B$.

2. W. W. of Amsterdam, *Zeitschrift für math. u. natur. Unterricht*, vol. 44, 1913, p. 557.

Draw $IG \| AC$, $IH \| BC$ so that IG and IH intersect AB, and $IG = AB = IH$. Then $\angle GIH = \angle C$, $\angle BAI = \angle CAI = \angle AIG$, and $\angle IGH = \angle IHG$

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[14] The same proof appeared in *Nyt Tidskrift for Mathematik*, vol. 4, Af. A, 1893, pp. 55 and *Amer. Math. Mo.*, vol. 2, 1895, p. 189.

[15] If two triangles have two sides of one equal to two sides of the other respectively, and the angles opposite to a pair of equal sides equal, then, if the angles opposite to the other pair of equal sides are of the same species, the two triangles are congruent. See T. L. Heath, *The Thirteen Books of Euclid's Elements*, 1926, vol. 1, pp. 306–307.

$=\frac{1}{2}(\angle A+\angle B)$. Now draw $KIJ \parallel AB$, and GA and HB to meet KJ at K and J respectively. Then $\angle KIA=\angle IAB=\frac{1}{2}\angle A$.

Since $IG=AB$, $AI=AI$ and $\angle AIG=\angle BAI$, $\triangle AIG\cong\triangle AIB$ and $\angle AGI=\angle ABI=\frac{1}{2}\angle B$. Further, $\triangle KIG\cong\triangle BAE$, since $IG=AB$, $\angle AGI=\angle ABI$, and $\angle KIG=\angle BAE$. Hence $KG=BE=AD$, $\angle IKG=\angle AEB=\angle C+\frac{1}{2}\angle B$. In like manner, $HJ=AD=BE$, $\angle IHB=\frac{1}{2}\angle A$ and $\angle IJH=\angle ADB=\angle C+\frac{1}{2}\angle A$.

Construct $\angle GKL=\frac{1}{2}\angle A$, $\angle HJM=\frac{1}{2}\angle B$, points L and M being on HG and GH prolonged. Since $KG=AD$, $\angle GKL=\angle BAD$ and $\angle KGL=180°-\angle KGI-\angle IGH=180°-\angle B-\frac{1}{2}\angle A=\angle C+\frac{1}{2}\angle A=\angle ADB$, then $\triangle KGL\cong\triangle ADB$ and in like manner, $\triangle JHM\cong\triangle AEB$. Hence $KL=BC=JM$, $\angle KLG=\angle B$, $\angle JMH=\angle A$. Thus $JKLM$ is an isosceles trapezoid and $\angle B=\angle KLG=\angle JMH=\angle A$, whence $AC=BC$.

The direct proof by G. I. Hopkins is so well known that we shall not reproduce it here. His earlier proof in the *Amer. Math. Mo.*, vol. 2, 1895, p. 57 contains a hidden assumption. See vol. 7, 1900, p. 226.

Indirect Proofs Based on Book I

1. Jacob Steiner, *Journal für die reine u. angewandte Mathematik*, vol. 28, 1844, p. 375.[16]

If $\angle A\neq\angle B$, say $\angle A>\angle B$, then in triangles ADB and AEB, $AD=BE$, $AB=AB$ and $\angle BAD>\angle ABE$. Hence $BD>AE$ and $\angle ADB>\angle AEB$.

Place $\triangle AEB$ on $\triangle ADB$ so that BA coincides with AB, B on A and A on B, and D and E are on opposite sides of AB. Then $\angle ADE'=\angle AE'D$ and hence $\angle BDE'>\angle BE'D$. Thus $BD<BE'=AE$ which contradicts the previous conclusion that $BD>AE$. Hence $\angle A=\angle B$.

2. Descube, *Journal de Mathématiques Élémentaires*, vol. 4, 1880, p. 538.[17]

Construct parallelogram $ADGE$ on the same side of AB as AD. If $\angle A\neq\angle B$, say $\angle A>\angle B$, then $BD>AE$, $EG=AD=BE$, $\angle BGE=\angle GBE$ and $\angle DGE=\angle DAE>\angle DBE$. Hence $\angle DGB<\angle DBG$ and $BD<DG=AE$. This is a contradiction of the conclusion $BD>AE$. Hence $\angle A=\angle B$.

3. Ernest Eckhardt, *Zeitschrift für math. u. natur. Unterricht*, vol. 35, 1904, p. 483.

Draw IG bisecting $\angle AIB$ and meeting AB at G, then $DH\parallel IG$ and $EK\parallel IG$ cutting BE and AD at L and M respectively and AB at H and K. Then triangles EIM and DIL are isosceles, $DM=EL$ and, as $AD=BE$, $AM=BL$. Further, $\angle AMK=\angle IEM=\angle IDL=\angle BLH$, and $\angle AME=\angle BLD$.

Each of the pairs of triangles ADH and BEK, AME and BLD, AMK and BLH, have a side and adjoining angle of one equal respectively to a side and adjoining angle of the other. In such triangles the side opposite the larger of the remaining adjoining angles is greater than the corresponding side of the other.

Assuming $\frac{1}{2}\angle A>\frac{1}{2}\angle B$ and applying this theorem, we have (a) $DH>EK$, (b) $DL<EM$, (c) $LH<MK$. Adding (b) and (c), $DH<EK$ which

[16] The above proof may be found in Todhunter's *Euclid*, 1886, p. 317, and in Halsted's *Synthetical Geometry*, 1893, p. 44.

[17] The same proof was given in *Journal de Mathématiques Élémentaires* (Vuibert), vol. 9, 1885, p. 132; *L'Intermédiaire des Mathématiciens*, vol. 2, 1895, p. 327; F. G. M. *Exercices de Géométrie*, 5th ed., 1912, p. 235; R. C. J. Nixon, *Euclid* Revised, 1890, p. 383. Substantially the same proof appeared in the, *Journal de Mathématiques Élémentaires*, 4th Series, vol. 4, 1895, p. 169, and in the *Amer. Math. Mo.*, vol. 24, 1917, p. 33, Descube's proof has been extended to the case when angles A and B are divided proportionally.

contradicts (a). Hence, since $\frac{1}{2}\angle A \not> \frac{1}{2}\angle B$ and, in like manner, $\frac{1}{2}\angle A \not< \frac{1}{2}\angle B$, we have $\angle A = \angle B$.

Two indirect proofs based on Book I have been given by V. Carpeneto and F. Guidice in *Periodico di Matematica*, vol. 7, 1892, p. 148 and vol. 8, 1893, p. 31. Proofs essentially the same as that given by Catalan, who proves in his *Théorèmes et Problèmes de Géométrie*, 6th ed., p. 6, that if $\angle A > \angle B$, then $AD < BE$,[18] were given in *Periodico di Matematica*, vol. 7, 1892, pp. 150, 189; *Supplemento al Periodico di Matematica*, 1899, p. 68; Wentworth's *Plane Geometry*, 1899, p. 70, Ex. 54, 55.

Direct Geometric Proofs Based on Book II

1. Proof attributed to DeGrainville by Barbarin in *Mathesis*, 2nd Series, vol. 6, 1896, p. 156.

Draw $DG \parallel BE$ and $EH \parallel AD$ to intersect the external bisector at C in G and H. Since $\angle CDG = \frac{1}{2}\angle B$ and $\angle ACG = \frac{1}{2}(\angle A + \angle B)$, then $\angle DGC = \frac{1}{2}\angle A$. Likewise, $\angle EHC = \frac{1}{2}\angle B$. Hence the quadrilaterals $ADCG$ and $BECH$ are cyclic and $\angle CAG = \angle CDG = \frac{1}{2}\angle B$, $\angle AGD = \angle C$, $\angle GAD = \angle DGA$ and $AG = GD$. In like manner, $\angle BHE = \angle C$, $\angle BEH = \angle EBH$ and $EH = BH$.

Since $\angle ABC + \angle ABH = 180°$, quadrilateral $ABHG$ is cyclic. Since $\triangle AGD \cong \triangle BEH$, then $AG = BH$. Quadrilateral $ABHG$ is an isosceles trapezoid with $\angle AGC = \angle BHC$, whence $\angle A = \angle B$.

2. W. H. L. Janssen van Ray, *L'Intermédiaire des Mathématiciens*, 2nd Series, vol. 2, 1923, p. 115.

The circles ADC and BEC which cut AB in G and H respectively are equal since $\angle ACD = \angle BCE$ and $AD = BE$. If m and n are the number of degrees in $\angle A$ and $\angle B$, then $\overset{\frown}{CD} = \overset{\frown}{DG} = m$, $\overset{\frown}{CE} = \overset{\frown}{EH} = n$. In circle BEC, $\angle BAC \overset{m}{=} \frac{1}{2}(\overset{\frown}{BC} - \overset{\frown}{EH})$ and $\overset{\frown}{BC} = 2m + n$, where $\overset{\frown}{BC}$ is the arc external to $\triangle ABC$. Likewise, using circle ADC, $\overset{\frown}{CA} = m + 2n$.

On the arcs BC and AC take points K and L respectively so that $\overset{\frown}{BK} = m + n = \overset{\frown}{AL}$ and draw the equal chords BK and AL. Then $\overset{\frown}{CK} = m$, $\overset{\frown}{CL} = n$ and in circle BEC, $\angle ABK \overset{m}{=} \frac{1}{2}\overset{\frown}{KEH} \overset{m}{=} \frac{1}{2}(m + 2n) \overset{m}{=} \frac{1}{2}\overset{\frown}{ALC}$. Hence $\angle ALC + \angle ABK = 180°$, and, in like manner, $\angle BAL + \angle BKC = 180°$.

If $ABKCL$ were a pentagon, then, since the sum of its angles is 540°, $\angle KCL = 180°$. Hence $ABKCL$ is a quadrilateral and, since it is cyclic, it is an isosceles trapezoid, Thus $\angle ABK = \angle BAL$, $2m + n = m + 2n$, whence $\angle A = \angle B$.

Another direct proof by V. Thébault appeared in *Mathesis*, vol. 51, 1937, p. 477.

Indirect Proofs Based on Book II

1. Rougevin, *Nouvelles Annales de Mathématiques*, vol. 1, 1842, p. 138.[19]

Construct circle ADC and place $\triangle BEC$ so that BE coincides with AD, B on D, E on A. Since $\angle BCE = \angle ACD$, $\triangle BEC$ will be inscribed in segment ACD, its vertex C falling on a point C', different from C, since $AC' = EC < AC$. The bisectors CI and $C'I'$ intersect at G, midpoint of arc AGD, and cut AD at I and I' so that $CI = C'I'$.

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[18] Two other proofs of this theorem may be found in *The Lady's and Gentleman's Diary*, 1860, p. 55 and *Supplemento al Periodico di Matematica*, 1899, p. 70.

[19] Similar proofs are to be found in *Journal de Mathématiques Élémentaires* (Vuibert), vol. 17, 1885, p. 130; *Supplemento al Periodico di Matematica*, 1899, p. 65. Modifications of the proof are given in *The Lady's and Gentleman's Diary*, 1857, p. 58; 1860, p. 86; *Math. Questions with their Solutions from the Educ. Times*, vol. 74, 1901, p. 107.

Draw diameter GH cutting AD at K. Then $\angle CGH = \angle C'GH$; for, if $\angle CGH \neq \angle C'GH$, say $\angle CGH > \angle C'GH$, then in right triangles CGH and $C'GH$, $\angle CHG < \angle C'HG$ and $CG < C'G$. Also from the right triangles IKG and $I'KG, IK > I'K$ and $IG > I'G$. Thus $CI > CI'$, which is impossible. Hence $\overset{\frown}{CH} = \overset{\frown}{C'H}$, $\overset{\frown}{CD} = \overset{\frown}{C'A}$, $\overset{\frown}{CA} = \overset{\frown}{C'D}$ and $CA = \overset{\frown}{C'D} = CB$.

2. Professor Lehmus, *Archiv der Mathematik u. Physik*, vol. 15, 1850, p. 225.[20]

If $\angle A \neq \angle B$, say $\angle A > \angle B$, then $\angle EAD > \angle DBE$. Construct $\angle DAG = \angle DBE$, AG cutting BE at G. Then $\angle BAG = \angle EAD + \angle DAG > \angle ABD$. Since $\angle DAG = \angle DBE$, points A, G, D, B, are concyclic and as $\angle BAG < 90°$, $BG > AD$. Hence $BE > AD$ which is impossible. Thus $\angle A = \angle B$.

Direct Proofs Based on Book III

18. H. Grout de Saint Parr, *Nouvelles Annales de Mathématiques*, vol. 1, 1842, p. 311.[21]

Construct circle BEC intersecting AD at H and CIF at L, the midpoint of $\overset{\frown}{EHB}$. Since $\triangle EIL \sim \triangle ECL$, $LI(LI+IC) = EL^2$.

Draw circle ADC, cutting BE at K and CIF at L'. Then L' is the midpoint of $\overset{\frown}{AKD}$. The circles ADC and BEC are equal, since $\angle ACD = \angle BCE$ and $AD = BE$. Hence $\overset{\frown}{EHB} = \overset{\frown}{AKD}$, $\overset{\frown}{EL} = \overset{\frown}{DL'}$, $EL = \overset{\frown}{DL'}$.

Since $\triangle DIL' \sim \triangle DCL'$, $L'I(L'I+IC) = DL'^2 = EL^2 = LI(LI+IC)$. Hence $L'I = LI$ and $L' \equiv L$, whence, since $\angle ALC = \angle BLC$, $\angle ACL = \angle BCL$, $BL = BL$, then $\triangle ACL \cong \triangle BCL$ and $AC = BC$.

2. Alfredo Schiappa Monteiro, *Jornal de Sciencias Mathematicas e Astronomicas*, vol. 8, 1887, p. 51.[22]

Draw DG making $\angle ADG = \frac{1}{2}\angle C$ and cutting IF at G. Then $\triangle IDG \sim \triangle IAC$ and $IG/ID = IA/IC$. Likewise, by drawing AG' to cut IF at G' so that $\angle DAG' = \frac{1}{2}\angle C$, we have $\triangle IAG' \sim \triangle ICD$, $IG/ID = IA/IC$. Hence $IG = IG'$ and $G \equiv G'$. In like manner, $\triangle BEH$, constructed congruent to $\triangle ADG$ has its vertex H on CIF between I and F.

Since $\angle DGI = \angle DGC$ and $\angle GDI = \angle DCG$, $\triangle DGI \sim \triangle DGC$ and $GD^2 = GI \cdot GC$. In like manner, $\triangle HEI \sim \triangle HEC$ and $HE^2 = HI \cdot DC$. Since $\triangle BEH \cong \triangle ADG$, $GD = HE$ and $GI \cdot GC = HI \cdot HC$.

Taking O, the midpoint of CI, for the origin of the segments, $(OG - OI)(OG + OC) = (OH - OI)(OH + OC)$, whence, $OG = OH$, $G \equiv H$ and points A, B, D, E are on a circle having G for center. Hence $\angle DAE = \angle DBE$ and $\angle A = \angle B$.

Indirect Proofs Based on Book III

1. Andrew Miller, Dundee, Scotland, 1866.[23]

If $\angle A \neq \angle B$, say $\angle A > \angle B$, draw AG, intersecting BC in G and BE in H, so that $\angle DAG = \angle GBH$. Since $\angle GAB > \angle GBA$, $GB > GA$. From the similar triangles GBH and GAD, $GB/GA = BH/AD$.[24] Then $BH > AD$

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[20] The same proof was given in *The Lady's and Gentleman's Diary*, 1860, p. 86; *The Anlayst*, vol. 6, 1879, p. 89; *Amer. Math. Mo.*, vol. 2, 1895, p. 190; vol. 5, p. 108. A variant appeared in the *Mathematical Gazette*, vol. 17, 1933, p. 125.

[21] This proof or variations of it were given in Gandt u. Junghause, *Sammlung von Lehrsätzen u. Aufgaben*, Zweiter Theil, 1870, p. 24; J. McDowell, *Exercises on Euclid*, 1878, p. 116; *Amer. Math. Mo.*, vol. 7, 1900, p. 227; *Math. Questions with their Solutions from The Educational Times*, vol. 74, 1901, p. 73; *L'Education Mathématique*, 1934, p. 129.

[22] The same paper contains a second proof.

[23] Reproduced by J. S. Mackay in the *Proc. Edinburgh Math. Soc.*, vol. 20, 1901–1902, p. 22.

[24] Loomis on his Original Investigation replaced this step by taking point K on BG so that $BK = AG$ and drawing $KL \parallel AG$ to cut BE at L, proved $\triangle BKL \cong \triangle ADG$, $BL = AD$ etc. See *Mathematical Gazette*, vol. 17, 1933, p. 125 where it is attributed to Casey.

and $BE > AD$ which is impossible. Hence $\angle A = \angle B$ and $AC = BC$.

2. *Journal de Mathématiques* (Vuibert), vol. 9, 1885, p. 131.

Draw $AG \| BE$ and $BH \| AD$ intersecting CB and CA prolonged in G and H respectively. Then $AH = AB = BG$.

If $\angle A \neq \angle B$, say $\angle B > \angle A$, then $AC > BC$, $\angle ABG < \angle HAB$ and $BH > AG$. Since $\triangle BEC \sim \triangle GAC$ and $\triangle ACD \sim \triangle HCB$,

$$AG/BE = CG/BC = (AB+BC)/BC = 1+AB/BC$$

$$BH/AD = CH/AC = (AB+AC)/AC = 1+AB/AC.$$

Hence as $AC > BC$, $AG/BE > BH/AD$ and $AG > BH$, a contradiction of the prior conclusion, $BH > AG$. Hence $\angle A = \angle B$.

3. R. v. Förster, *Unterrichtsblätter für Mathematik u. Naturwissenschaften*, vol. 21, 1915, p. 97.[25]

Draw $CG \| AD$, $CH \| BE$, meeting BA and AB prolonged at G and H respectively. Then $AD/AB = CG/BG$, $BE/AB = CH/AH$ and hence $CG/CH = BG/AH$. Also, since $AG = AC$ and $BH = BC$, $CG/CH = (CA+AB)/(CB+AB)$.

If CK, the bisector of $\angle GCH$ meets AB in K, and assuming $AC \neq BC$, say $AC < BC$, we have

$$GK/KH = CG/CH > CA/CB,$$

$$(CA+AK)/CA > (CB+BK)/CB, \qquad AK/CA > BK/CB.$$

Since $AK/BK > CA/CB = AF/BF$, then $AK/AF > BK/BF$.

But $\angle A > \angle B$, $\angle GCK < \angle GCF$ and K lies nearer A than F. Thus $AK/AF < 1$ and $BK/BF > 1$, which is impossible, and hence $AC = BC$.

For other indirect proofs based on theorems in Book III see B. L. Smith and J. J. Sylvester in *London, Edinburgh and Dublin Philosophical Magazine*, 4th Series, vol. 4, 1852, pp. 366, 367; C. Soschino, *Periodico di Mathematica*, vol. 7, 1892, p. 188.

Direct Proofs Based on Book IV

1. J. Newell, *The Mathematical Gazette*, vol. 16, 1932, p. 200.

Produce AB to G and BA to K so that $BG = AC$, $AK = BC$, and draw $GH \perp AD$ at H, $KL \perp BE$ at L, and $IF \perp AB$.

Then $KF = KA + AF = BC + AF = s = CA + BF = GB + BF = FG$, $\triangle KIG$ is isosceles, $IK = IG$, $\angle IKF = \angle IGF$. Since $AK = BC$ and the altitudes from E are equal, $\triangle AEK = \triangle BEC$. Thus $\triangle KEB = \triangle KEA + \triangle AEB = \triangle BEC + \triangle AEB = \triangle ABC$. In like manner, $\triangle ADG = \triangle ABC$.

Hence $\triangle KEB = \triangle ADG$ and since $BE = AD$, then $KL = GH$. Thus $\triangle GHI \cong \triangle KLI$ and $\angle HIG = \angle KIL$. Now $\frac{1}{2}\angle A + \angle IGF = \angle HIG = \angle KIL = \frac{1}{2}\angle B + \angle IKF$. Hence $\frac{1}{2}\angle A = \frac{1}{2}\angle B$ and $AC = BC$.

Two other proofs by means of theorems in Book IV were given by J. Dobbs in the same periodical, vol. 17, 1933, p. 244 and V. Thébault, *The American Mathematical Monthly*, vol. 45, 1938, p. 307. In connection with the latter proof we would point out that when a triangle has two equal external bisectors, the triangle is not necessarily isosceles.

A More General Form of the Theorem

If, in $\triangle ABC$, AD and BE divide angles A and B so that $\angle BAD / \angle DAC = \angle ABE / \angle EBC$ and $AD = BE$, then $\triangle ABC$ is isosceles.[26]

[25] A note calls attention to the fact that an earlier proof in *Archiv der Mathematik u. Physik*, 1850, pp. 358–360 has two errors.

[26] Jacob Steiner, *Journal für die reine u. angewandte Mathematik*, vol. 28, 1844, p. 375. A proof using Steiner's method was given by C. Schmidt in *Archiv der Mathematik u. Physik*, vol. 18, 1852, p. 357.

1. R. Baltzer, *Archiv der Mathamatik u. Physik*, vol. 16, 1851, p. 201.

First, if $\angle A \neq \angle B$, say $\angle A < \angle B$ and $\angle CAD = \angle CBE$, then $AD > BE$; for $\triangle ACD \sim \triangle BCE$, $AC > BC$ and hence $AD > BE$.

Second, if $\angle A < \angle B$ and $\angle BAD < \angle ABE$ and $\angle CAD < \angle CBE$ then $AD > BE$; for, by drawing BC' to cut AC in C' and AD in D' so that $\angle C'BE = \angle C'AD'$, then by the preceding statement $AD' > BE$ and hence $AD > BE$.

In both cases the hypothesis, $AD = BE$, is contradicted and hence $\angle A = \angle B$.

2. Dr. August, *Archiv der Mathematik u. Physik*, 1851, vol. 16, p. 259.

If $\angle A \neq \angle B$, say $\angle A > \angle B$, draw AH to cut BC in H so that $\angle CAH = \angle CBE$. Then $AC < BC$, $\triangle BCE \sim \triangle ACH$, $AC/BC = AH/BE$ and $AH < BE$.[27]

Now draw AG to cut BC in G so that $\angle GAB = \angle EBA$. In triangles GAB and EAB, since $AB = AB$, $\angle GAB = \angle EBA$ and $\angle A > \angle B$, then $AG > BE$. As $\angle DAC > \angle CBE = \angle CAH$ and $\angle DAB > \angle EBA = \angle GAB$, then AD falls between AH and AG.

Now AD is less than the larger of the two lines AH and AG or smaller than both, if $AH = AG$. Since both AH and AG are less than BE, then $AD < BE$, which is impossible. Hence $\angle A = \angle B$.

Another proof may be found in *Archiv der Mathematik u. Physik*, vol. 16, 1851, p. 355.

Trigonometric Proofs

1. A. Niegeman, *Archiv der Mathematik u. Physik*, vol. 41, 1864, p. 151.

Draw $AG \perp BC$, $BH \perp AC$. Then $AG = AD \sin ADG = AD \sin (C + \frac{1}{2}A) = AD \cos \frac{1}{2}(B - C)$.

$$BH = BE \sin BEH = AD \sin (C + \tfrac{1}{2}B) = AD \cos \tfrac{1}{2}(A - C).$$

Now $\triangle AGC \sim \triangle BHC$ and $AC/BC = AG/BH = \cos \frac{1}{2}(B - C)/\cos \frac{1}{2}(A - C)$. If $BC \neq AC$, say $BC > AC$, $\angle A > \angle B$ and $\cos \frac{1}{2}(A - C) > \cos \frac{1}{2}(B - C)$. Hence $A - C < B - C$ and $\angle A < \angle B$ which is impossible. Hence $AC = BC$.

2. Dr. Krüger, *Zeitschrift für math. u. natur. Unterricht*, vol. 24, 1893, p. 439.

Set $\angle CAB = 2\phi$, $\angle CBA = 2\theta$. Then $\sin (2\phi + \theta)/\sin 2\phi = c/t_b$, $\sin (2\theta + \phi)/\sin 2\theta = c/t_a$ and $\sin (2\phi + \theta)/\sin 2\phi = \sin (2\theta + \phi)/\sin 2\theta$.[28]

$$(\cos \phi - \cos \theta)\,(\sin^2\phi \sin^2\theta + \cos \phi \cos \theta + \cos^2\phi \cos^2\theta - \tfrac{1}{2} \sin 2\phi \sin 2\theta) = 0.$$

$$(\cos \phi - \cos \theta)\,[\cos^2 (\phi + \theta) + \cos \phi \cos \theta] = 0. \qquad (A)$$

Hence $\cos \phi - \cos \theta = 0$ and, as ϕ and θ are acute angles, $\phi = \theta$ and $AC = BC$.

The other factor can equal zero for real angles only if $\cos \phi \cos \theta$ is negative. Hence one angle, say ϕ, is obtuse and the other angle, θ, is acute. The angle 2ϕ is a reflex angle, formed by AB and CA prolonged. whose bisector is identical with the external bisector of $\angle BAC$. Hence $2\phi = 180° + A$, $2\theta = B$ and from (A) the general condition, that $t_b' = t_a$ is $\cos^2 \frac{1}{2}C = \sin \frac{1}{2}A \cos \frac{1}{2}B$.

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[27] A proof which obtains this step by means of Book I and independent of parallel lines and the sum of the angles of a triangle, but otherwise the same, was given by H. F. Blichfeldt in *Annals of Mathematics*, 2nd Series, vol. 4, 1902–1903, pp. 22–24. Another proof, independent of the parallel postulate, was given by G. Tarry in *Journal de Mathématiques Élémentaires*, 4th series, vol. 4, 1895, p. 169.

[28] A variation of this proof was given by Zerr in the *Amer. Math. Mo.*, vol. 2, 1895, p. 189. Setting $x = \sin \phi$, $y = \sin \theta$, he obtained an equation of the sixth degree with the factor $x^2 - y^2$.

3. P. von Schwaewen, *Zeitschrift für math. u. natur. Unterricht*, vol. 24, 1893, p. 438.

From $t_a(b+c) \sin \frac{1}{2}A = 2\Delta = t_b(a+c) \sin \frac{1}{2}B$,[29] we have $(\sin B + \sin C) \sin \frac{1}{2}A = (\sin A + \sin C) \sin \frac{1}{2}B$ or $\sin C(\sin \frac{1}{2}A - \sin \frac{1}{2}B) + (\sin B \sin \frac{1}{2}A - \sin A \sin \frac{1}{2}B) = 0$. (A)

Now $\sin B \sin \frac{1}{2}A - \sin A \sin \frac{1}{2}B = 2 \sin \frac{1}{2}A \sin \frac{1}{2}B(\cos \frac{1}{2}B - \cos \frac{1}{2}A)$. Also $\cos \frac{1}{2}B - \cos \frac{1}{2}A = 2 \sin \frac{1}{4}(A+B) \sin \frac{1}{4}(A-B) = [2 \sin \frac{1}{4}(A+B) / \cos \frac{1}{4}(A+B)] \sin \frac{1}{4}(A-B) \cos \frac{1}{4}(A+B) = \tan(45° - \frac{1}{4}C)(\sin \frac{1}{2}A - \sin \frac{1}{2}B)$.

Substituting in (A), we have

$$(\sin \tfrac{1}{2}A - \sin \tfrac{1}{2}B)[\sin C + 2 \sin \tfrac{1}{2}A \sin \tfrac{1}{2}B \tan(45° - \tfrac{1}{4}C)] = 0.$$[30]

Hence $\sin \frac{1}{2}A = \sin \frac{1}{2}B$ and $\angle A = \angle B$.

4. V. Ferroni and M. Fusconi, *Supplemento al Periodico di Matematica*, 1899, p. 70.

From $\quad t_a/a_1 = \sin B / \sin \frac{1}{2}A \quad$ and $\quad a_1 = \dfrac{ac}{b+c}$,

we have $$t_a = \frac{ac \sin B}{(b+c)\sin \frac{1}{2}A} = \frac{bc \sin A}{(b+c)\sin \frac{1}{2}A} = \frac{2bc}{b+c} \cos \tfrac{1}{2}A = \frac{2c}{1+\dfrac{c}{b}} \cos \tfrac{1}{2}A.$$

In like manner, $$t_b = \frac{2c}{1+\dfrac{c}{a}} \cos \tfrac{1}{2}B.$$

If $a \neq b$, say $a > b$, then $\frac{1}{2}A > \frac{1}{2}B$, $\dfrac{c}{b} > \dfrac{c}{a}$ and $\dfrac{2c}{1+\dfrac{c}{b}} < \dfrac{2c}{1+\dfrac{c}{a}}$.

Since $\frac{1}{2}\angle A < 90°$, then $\cos \frac{1}{2}A < \cos \frac{1}{2}B$ and $t_a < t_b$ which is impossible. Hence $a = b$.

Other trigonometric solutions have been given by M. Sacchi, *Periodico di Matematica*, vol. 7, 1892, p. 147[31]; T. Roach, *Mathematical Questions with their Solutions from the Educational Times*, vol. 74, 1901, p. 73; Paul Capron, *American Mathematical Monthly*, vol. 24, 1917, p. 34.

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2. *Annals of Mathematics*, 2nd Series, vol. 4, 1902, p. 22.
3. *Archiv der Mathematik u. Physik*, vol. 3, 1843, p. 445; vol. 20, p. 470; vol. 37, 1861, p. 455.
4. *Bulletin de Sciences Mathématiques et Physiques Elémentaires*, vol. 9, 1904, pp. 146, 192; vol. 12, 1907, p. 22.
5. *Bulletin de Société de Mathématiques de France*, vol. 22, 1894, p. 76.
6. *Jornal de Sciencias Mathematicas e Astronomicas*, vol. 8, 1887, p. 51.

[29] See M. Simon, *Über die Entwicklung der Elementar-Geometrie im XIX Jahrhundert*, 1906, p. 132.

[30] It can be shown that the second factor is greater than zero.

[31] A geometric proof by A. Seebeck in *Archiv der Mathematik u. Physik*, vol. 16, 1851, p. 202, used the same principle.

7. *Journal de Mathématiques Élémentaires* (Bourget), 4th Series, vol. 4, 1895, p. 169.
8. *Journal de Mathématiques* (Vuibert), vol. 9, 1885, pp. 128, 130.
9. *L'Education Mathématique*, vol. 32, 1929–1930, p. 57; vol. 34, 1931–1932, pp. 65, 105; vol. 35, 1932–1933, pp. 129, 153.
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15. *Nyt Tidskrift for Mathematik*, vol. 4, Af.A, 1893, p. 55.
16. *Periodico di Matematica*, vol. 7, 1892, pp. 147, 187; vol. 8, 1893, pp. 31, 119, 186.
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19. *Zeitschrift für math. u. natur. Unterricht*, vol. 23, 1892, pp. 480, 579; vol. 24, 1893, p. 438; vol. 25, 1894, pp. 116, 583; vol. 26, 1895, p. 173; vol. 29, 1898, p. 91; vol. 31, 1900, p. 104; vol. 35, 1904, p. 483; vol. 44, 1913, p. 557.
20. C. Adams, *Die merkwürdigsten Eigenschaften des geradlinigen Dreiecks*, 1846, pp. 10–11.
21. A. Emmerich, *Pseudogleichschenklige Dreiecke im Bereich der Winkelhalbierenden.* (Beilage zum Jahresbericht 1907 des Gymnasiums u. der Realschule zu Mülheim a. d. Ruhr)
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23. E. Marx, *Über winkelhalbierende Linien des Dreiecks*, Programm des Gymnasiums zu Friedland, 1905.
24. J. Neuberg, *Bibliographie des Triangles Speciaux*, pp. 9, 36.
25. M. Simon, *Über die Entwicklung der Elementar-Geometrie im XIX Jahrhundert*, 1906, p. 132.

HYDROGEN BACTERIA

Hydrogen bacteria, inhabitants of the soil which feed in part on hydrogen gas, have been indicated as possible important factors in soil fertility, in researches by Prof. P. W. Wilson, Dean E. B. Fred and their associates at the University of Wisconsin.

When crop residues decompose in the soil, hydrogen gas is frequently liberated. It was demonstrated that hydrogen is a specific inhibitor for nitrogen fixation by leguminous plants, and thus the presence of hydrogen in the soil atmosphere would reduce the efficiency of the nitrogen fixation process.

The bacteria make hydrogen harmless by combining it with oxygen to form water. To this extent hydrogen bacteria are helpful, but certain strains are able to take oxygen from nitrates and sulfates, even in the presence of oxygen, forming reduced compounds which are injurious to plant growth. This process lowers the fertility of the soil.

APPROXIMATE NUMBERS

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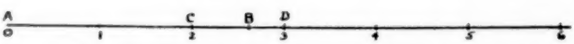
There is a crying need for the teaching of approximate numbers—their meaning and use. Even college students who major in mathematics ignore this field of work. In our high schools teachers of mathematics are diffident about teaching this topic mainly because the literature on the subject is not clear-cut and because they consider it too difficult for high school pupils.

Recently a chart was made up by one of our big automobile manufacturers entitled "The application of mathematics in the design of Chevrolet cars and trucks." Problem 2 on this chart gives the solution of the following problem: "Determine the periphery of an elliptical section through a hand brake lever." Although the measurements are given as $\frac{3}{4}''$ for the semi-major axis and $\frac{1}{2}''$ for the semi-minor axis, the final answer gives the perimeter as $3.96941160''$! Do the measurements as given warrant a degree of accuracy in the result to the nearest hundred-millionth of an inch? Evidently the one who computed this problem never studied how to handle approximate numbers.

Books and articles that discuss approximate numbers assume that in reading a measurement we cannot read better than to the nearest smallest subdivision of the scale, and that we indicate a possible error of one-half of one of the smallest subdivisions of the scale.



To take a striking case, if the scale is graduated to inches, they would in accordance with the above principle read the distance AB as $3''$ with a possible error of $0.5''$. Obviously this reading does not take full advantage of our measuring instrument. The point B is a little more than midway between C and D, and it is safe to read the distance AB as $2.6 \pm 0.1''$. If we use a scale graduated to tenths we can read to hundredths with a possible error of one or two hundreths in either direction. This method of reading agrees with laboratory practice and with common sense.

In order to encourage the mathematics teachers of Tilden High School to teach this topic in their algebra classes, the following material is given to each teacher with the under-

standing that "approximate numbers" is one of the topics on which pupils will be examined. Perhaps a careful reading of this article will tempt others to teach this important subject in their own classes.

When we compute with numbers we must distinguish between numbers obtained by counting and those obtained by measurement. The first are always exact, while all numbers obtained by measurement and most numbers appearing in mathematical ables are only approximate. In the case of an approximate number it is important to know how accurate it is, which figures are significant, what is the probable error, the relative error and the per cent error.

We must realize that no measurement is perfect. If we measure a line and find that it is 5″ long, it is quite possible that if we had used a ruler with sufficiently minute graduations we would have found this line to be 5.001″. How accurate a measurement is depends on the instruments that we use. Suppose we are asked to measure the length of a certain line-segment drawn on a sheet of graph paper, and suppose for convenience that there are ten boxes to one unit.

Then $AB = 1.3 + \text{a little distance } CB$
CB is approximately .6 of .1 or .06
$\therefore AB = AC + CB = 1.3 + .06 = 1.36$ approximately.

We are sure of the figures 1 and 3 but we are not sure of the 6. The last figure is an estimate, and it may be off 1 or more, in either direction, depending upon the accuracy of the rulings. The digits 1 and 3 are called certain, but 6 is called an uncertain digit. We say that 1.36 has three significant figures. Significant figures of a measured result are those that have some meaning. (We shall presently return to this important matter of significant figures.)

$$\text{The relative error} = \frac{\text{probable error}}{\text{numerical value under consideration}}.$$

In the above illustration, if we assume the error to be $\pm .01$, then the relative error $= \frac{0.01}{1.36} = \frac{1}{136}$.

$$\text{The \% error} = \frac{1}{136} \times 100 = \text{about } 0.7\%.$$

Significant Figures

Figures which are necessary to indicate the precision of a measurement or to determine the relative error of the measurement are called significant figures. The digits 1–9 inclusive are always significant, and so are zeros placed between any two of them or at the end of a decimal fraction. But zeros are never significant when there are no other digits to the left of them. Thus, as measurements,

6.03 has three significant figures 6, 0, 3.
.063 has two significant figures 6, 3.
6.30 has three significant figures 6, 3, 0.

Measurements which have the same digits and the same relative error have the same number of significant figures.

Thus, 0.528	has a relative error of 1/528	assuming in each case that the digit 8 has a probable error of ± 1.
5.28	has a relative error of 1/528	
52.8	has a relative error of 1/528	
528	has a relative error of 1/528	

and each has three significant figures.

On the other hand a measurement of 0.5 has a relative error of 1/5; a measurement of 0.50 has a relative error of 1/50; a measurement of 0.500 has a relative error of 1/500. Hence 0.500 as a measure is 100 times as precise as 0.5. It has three significant figures, whereas 0.5 has only one.

In the case of zeros at the end of a whole number we cannot tell which of them, if any, are significant unless we know how precisely the measurements were made. Thus, take the distance from the earth to the sun to be 92,600,000 miles. If the measurement is correct only to the nearest hundred thousand miles, then none of the zeros is significant and the number has only three significant figures. We then write it as 9.26×10^7. If it is correct to the nearest ten thousand miles it has four significant figures, and is written as 9.260×10^7.

Computation with Approximate Numbers

Strictly speaking each measurement should be accompanied by a statement of its probable error. Otherwise we shall assume that the digit on the extreme right is doubtful, and has an error of 1 in either direction. The following examples will indicate a good enough practical method of computing with approximate numbers, without the use of subtle and elaborate rules. It is the method most frequently used for ordinary work in chemistry and physics laboratories.

Ex. 1. The dimensions of a rectangle are 23.42 ft. and 7.17 ft. Find the area.

Since the per cent error in our least accurate measurement (7.17) is approximately 0.14%, the per cent error of the result should be approximately the same. Multiplying 23.42 by 7.17 we obtain 167.9214. Hence the answer should be written 167.9. Note that the per cent error in our final result is about 0.06%. Had we called our answer 168, the per cent error would have been about 0.6% and would have done an injustice to our measurements. Thus the per cent error is a safer criterion for judging the number of digits to retain than the number of significant figures, although the latter is an approximately good guide.

Ex. 2. What is the volume of a cube whose edge is 9.3″?

$$9.3 = 9.3 = 86.49 = 86 \text{ to two significant figures.}$$
$$86 \times 9.3 = 799.8 = 800 \text{ to two significant figures.}$$

Hence the answer is 800 cu. in., correct to two significant figures. Note that the last zero is not significant. Note also that the per cent error in 9.3 is about 1%, and that the per cent error in 800 is about 1% (since the last zero is not significant).

Ex. 3. What is the perimeter of a quadrilateral whose sides are 0.7″, 7.6″, 9.8″, 11.7″?

$$\begin{array}{r} 0.7 \\ 7.6 \\ 9.8 \\ \underline{11.7} \\ 29.8 \pm 0.4 \end{array}$$

Assuming the error in each measurement to be ± 0.1, the possible error in the sum may be as large as 0.4. The per cent error in the sum is about 1%, whereas the per cent error in 0.7 is about 14%. Hence we note that in the case of addition the sum as written may be better than some of the measurements.

Ex. 4. Change 52.6″ to centimeters. 1 centimeter equals .3937″ approximately.

$$\therefore \quad \frac{52.6}{.3937} = 133.6 \textit{ Ans.}$$

The per cent error in 52.6 is about 0.2%.

The per cent error in 133.6 is about 0.1%. (See comment in connection with example 1.)

Ex. 5. Change 98.6°F. to centigrade.

$$C = \frac{5}{9}(F-32)$$

$$C = \frac{5}{9}(98.6-32)$$

$$C = \frac{5}{9}(66.6)$$

$$C = 37.0 \text{ degrees} \quad \textit{Ans.}$$

The per cent error in 98.6 is about 0.1%.

The per cent error in 37.0 is about 0.3%.

Note that the answer is not 37, for then the per cent error would be about 3%, which would be much too large. Note also that the numbers 5 and 9 in the formula are *exact* numbers.

Ex. 6. Find the circumference of a circle whose diameter is 2.25″. π is a numerical coefficient whose value has been calculated to very many decimal places. Therefore the measured distance 2.25 is much less reliable than the value of π. Hence $3.142 \times 2.25 = 7.06950 = 7.07''$. The per cent error is about $\frac{1}{2}$%. The per cent error in 7.07 is about 1/7%.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problems, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1592. *James G. Go, Cebu, Cebu, P. I.*

1594. *D. L. MacKay, New York.*

1596. *D. L. MacKay, New York.*

1597. *James G. Go, Cebu, Cebu, P. I.*

1589. *Hugo Brandt, Chicago.*

Errors in statements of Problems for Solution, April Issue.

In problem 1604 the index of the radical should be $i(\sqrt{-1})$. In 1605 the problem should read: For the curve 3 arc tan y/x. . . . In 1606, the zero of the denominator should be replaced by 1. In 1607 the exponent of 27 should be k.

1598. *Proposed by Cecil B. Read, University of Wichita, Kansas.*

Solve for x and y:

$$(x+y)(xy+1)=18xy$$
$$(x^2+y^2)(x^2y^2+1)=208x^2y^2.$$

Note: This problem appears in Ray's *Algebra for High Schools and Colleges* (1852). It would be interesting to find out how many high school or college students of the present time can solve this. The solution as offered in Ray's *Algebra* is incomplete.

Solved by the Proposer

Let $x+y=s$ and $xy=p$

Then $$s(p+1)=18p \tag{1}$$
and $$(s^2-2p)(p^2+1)=208p^2. \tag{2}$$

Square (1) and subtract (2)

$$2p(p^2+s^2+1)=116p^2.$$

Then $p=0$ gives the obvious solution $x=0$, $y=0$.

$$p^2+s^2+1=58p$$
$$2s(p+1)=36p \qquad \text{from (1)}$$
$$2p=2p.$$

Adding

$$(p+s+1)^2=96p$$
$$p+s+1=\pm 4\sqrt{6p}$$
$$p+1=\frac{18p}{s} \qquad \text{from (1)}$$

$$s=\pm 4\sqrt{6p}-\frac{18p}{s}$$

$$s^2 \pm 4s\sqrt{6p}+18p=0$$

$$s=\pm 3\sqrt{6p} \quad \text{or} \quad \pm\sqrt{6p}$$

Substituting s in (1)

$$p+1=\pm\sqrt{6p} \quad \text{or} \quad p+1=\pm 3\sqrt{6p}$$

$$p=2\pm\sqrt{3} \quad \text{or} \quad p=26\pm 15\sqrt{3}$$

$$s=9\pm 3\sqrt{3} \qquad s=9\pm 5\sqrt{3}$$

$$\left.\begin{aligned} x+y&=9+3\sqrt{3} \\ xy&=2+\sqrt{3} \end{aligned}\right\} A \qquad \left.\begin{aligned} x+y&=9\pm 5\sqrt{3} \\ xy&=26+15\sqrt{3} \end{aligned}\right\} C$$

$$\left.\begin{aligned} x+y&=9-3\sqrt{3} \\ xy&=2-\sqrt{3} \end{aligned}\right\} B \qquad \left.\begin{aligned} x+y&=9-5\sqrt{3} \\ xy&=26-15\sqrt{3} \end{aligned}\right\} D$$

From A, B, C, and D we have the nine solutions.

$$x=7\pm 4\sqrt{3} \quad \text{or} \quad 2\pm\sqrt{3}$$

$$y=2\pm\sqrt{3} \quad \text{or} \quad 7\pm 4\sqrt{3}$$

and $x=y=0$ as previously found.

Solutions were also offered by D. L. MacKay, New York, M. Kirk, West Chester, Pa., Walter R. Warne.

1599. *Proposed by Walter R. Warne, Minneapolis.*

A and B agree to reap a field in 7 days for \$60. After working together for 5 days they call in C to finish the job in 7 days. As a result A receives \$4-5/7 less and B \$6-2/7 less than originally planned. In what time could each do the work?

Solution by Edward C. Varnum, Clyde, Ohio

C earns \$11 in two days, so he does 11/60 of the job in that time, or 11/120 in one day. Thus C could do it alone in 120/11 days, or 10-10/11 days.

The losses of A and B are in the ratio of 3:4 and they receive together \$49. Dividing this amount in the given ratio, A receives \$21 and B \$28. Because the former earns \$21 in 7 days, he does 3/60 or 1/20 of the task in one day, whereas the latter does 4/60 or 1/15 in one day. Thus A could reap the field alone in 20 days and B in 15 days.

Solutions were also offered by William E. Brooke, University of Minnesota, Paul H. Renton, Trafford, Pa., Charles W. Trigg, Los Angeles, John Wagner, Chicago, M. Kirk, West Chester, Pa., W. R. Smith, Lewis Institute, Chicago, B. F. John, Pittsburgh, Pa., Charles Greeive, Kenadaia, New York, Mrs. Walter R. Warne, Minneapolis and also by the proposer.

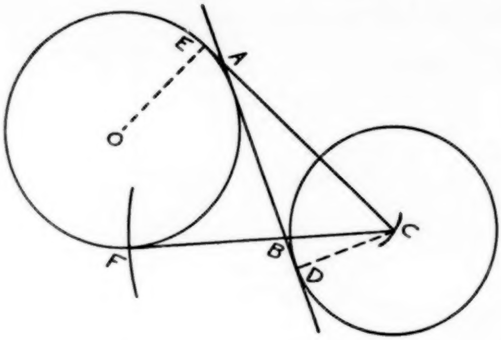
1600. *Proposed by William Taylor, Port Arthur, Texas.*

Construct a triangle, given the perimeter, the altitude to the base, and the exradius relative to the base.

Solution by Charles W. Trigg, Los Angeles City College

Given: s, h_c and r_c.

Construction: With a radius $OE=r_c$ describe a circle. At any point E on the circle erect a perpendicular to the radius OE. With E as center and a radius equal to s, describe an arc cutting the perpendicular at C. With C as center and the same radius describe an arc cutting the circle at F. Draw CF. With C as center and a radius $CD=h_c$ describe a circle. In the well-known manner construct the common internal tangent to the two circles, cutting CE at A and CF at B. ABC is the required triangle.



Proof: AB is tangent to the second circle at D so the radius $CD=h_c$ is perpendicular to AB and is an altitude of $\triangle ABC$. The circle with center O and radius r_c is tangent to AB and to CA and CB extended, hence it is an escribed circle of the triangle. Now the distance of a vertex of a triangle from the point of contact of the excircle relative to this vertex with a side issued from the vertex considered equals half the perimeter of the triangle. Since $CE=CF=s$ by construction, the semiperimeter of $\triangle ABC=s$.

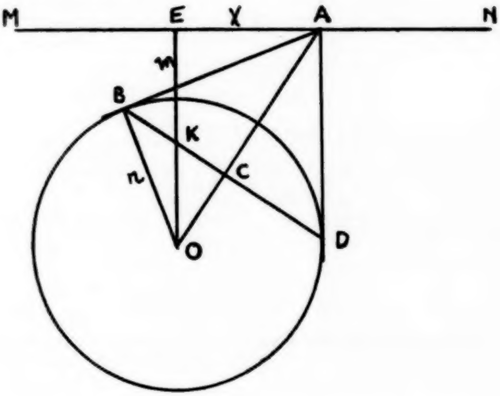
Solutions were also offered by Paul D. Thomas, Norman, Okla., M. Kirk, West Chester, Pa., D. L. MacKay, New York, Boris Garfinkel, Buffalo, N. Y. Ida Mae Myers, Norman, Oklahoma, Mrs. Walter R. Warne, Minneapolis, Edward C. Varnum, Clyde, Ohio, and also by the proposer.

1601. *Proposed by John N. Meighan, Storer College, Harpers Ferry, W. Va.*

AB and AD are lines tangent to circle O at B and D respectively. C is the mid-point of line segment BD. Find the locus of point C as A moves on a straight line which does not intersect circle O.

Solution by Aaron Buchman, Buffalo, N. Y.

Let MN be the line along which A moves.
Draw $OE\perp MN$, and draw OB and OA. (OA passes through C.)
Let OE intersect BD at K.



Let $OB=r$, $OE=m$, and variable $EA=x$.
Then $OA=\sqrt{m^2+x^2}$.
Since $\triangle OBC \sim \triangle OBA$

then $$\frac{OC}{OB}=\frac{OB}{OA}$$

and $$OC=\frac{r^2}{\sqrt{m^2+x^2}}.$$

Since $\triangle OKC \sim \triangle OEA$

then $$\frac{OK}{OA}=\frac{OC}{OE}$$

and $$OK=\frac{r^2}{m}, \quad \text{a constant,}$$

so that K is a fixed point.

Since $\angle OCK$ is a right angle and O and K are fixed points, then the locus of C is a circle upon OK as diameter.

Solutions were also offered by Walter R. Warne John P. Hoyt, Cornwall, New York, Edward C. Varnum, Clyde, Ohio, D. L. MacKay, New York, Charles W. Trigg, Los Angeles, Boris Garfinkel, Buffalo, N. Y., also by the proposer.

1602. *Proposed by Norman Anning, Ann Arbor, Michigan.*

Show that nothing beyond the properties of similar triangles is necessary for establishing the "intercept" form of the equation of the plane:

$$(x/a)+(y/b)+(z/c)=1.$$

Solution by Boris Garfinkel, Buffalo, N. Y.

Through the point $P(x, y, z)$ pass a plane RMN parallel to the plane AOB. From similar triangles:

(1) $$\frac{RM}{OA}=\frac{RN}{OB}=\frac{RC}{OC}$$

(2) $$\frac{SP}{RM}=\frac{PN}{MN} \quad \text{and} \quad \frac{TP}{RN}=\frac{PM}{MN}.$$

Adding the last pair of equations we obtain

(3) $$\frac{SP}{RM}+\frac{TP}{RN}=1.$$

Eliminating RM and RN by means of (1) gives

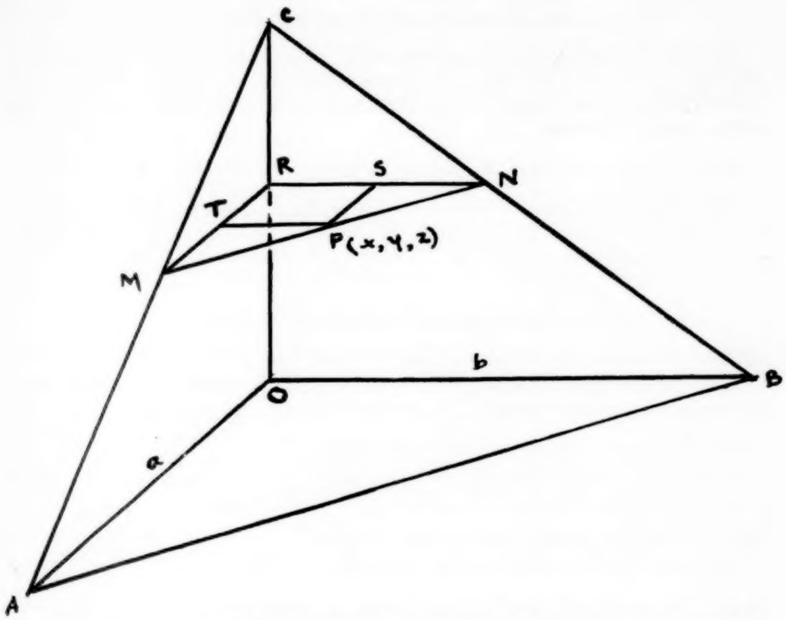
(4) $$\frac{SP}{OA}+\frac{TP}{OB}=\frac{RC}{OC}.$$

Since $RC=OC-OR$

(5) $$\frac{SP}{OA}+\frac{TP}{OB}+\frac{OR}{OC}=1,$$

which in the usual notation becomes

(6) $$\frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1.$$



Solutions were also offered by W. R. Warne, Minneapolis, Carl Noble, University of Iowa, Edward C. Varnum, Clyde, Ohio, William E. Brooke, University of Minnesota, and also by the proposer.

1603. *Proposed by Charles P. Louthan, Columbus.*

Given a triangle ABC with D and E on sides BA and BC respectively. If DE is the shortest line dividing the triangle into two equivalent parts, calculate BE and BD in terms of a and b where $a = BA$, $b = BC$.

Solution by Aaron Buchman, Buffalo, N. Y.

Since, of all the triangles with a given base and given vertex angle, the isosceles triangle upon this base has the greatest altitude, and therefore the greatest area, it is easily shown, by the indirect method, that of all such triangles, the isosceles triangle has the smallest base.

Thus $BD = BE = x$.

Since the area of $\triangle BDE = \frac{1}{2}$ the area of $\triangle ABC$

$x^2 \sin B = \frac{1}{2}\, a \cdot b \cdot \sin B$

and $x = \frac{1}{2}\sqrt{2ab}$.

Note: The indirect proof mentioned above, is as follows. Suppose triangle XBZ is not isosceles and has the given area K, given vertex angle B and smallest base XZ. Then it is possible, by circumscribing a circle, to get isosceles triangle $XB'Z$ upon XZ as base with angle B' equal to angle B, whose area is greater than triangle XBZ, say $K + k$. Let $X'Z' \| XZ$ cut off triangle $X'B'Z'$ with area K. Then $X'Z < XZ$, a contradiction. Thus triangle XBZ must be isosceles.

Solutions were also offered by Charles W. Trigg, Los Angeles, W. R. Warne, Minneapolis, Arthur Danzl, Collegeville, Minn., D. L. MacKay, New York, M. Kirk, West Chester, Pa., Edward C. Varnum, Clyde, Ohio, Mrs. Walter Warne, Minneapolis, W. R. Brooke, University of Minnesota, Garland D. Kyle, Knoxville, Tenn.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department Teachers are urged to report to the Editor such solutions.

1599. *Ralph Coughlan, Archmere Academy, Claymount, Del.*

1600. *Gerald Gifford, Lewis and Clark High School Spokane, Wash., R. D. Minckler, S. C. Peterman, F. M. Morens, W. T. Tucker, R. C. Carnright, R. S. LaVienx and E. M. Flanagan all of Cornwall, New York.*

PROBLEMS FOR SOLUTION

1616. *Proposed by C. W. Trigg, Los Angeles City College.*

Find the two permutations of the ten digits which are multiples of 1901 and are also perfect squares. Show that they are the only ones.

1617. *Proposed by I. N. Warner, Platteville, Wis.*

How many one inch balls can be placed in a rectangular box which measures inside 5 in. by 10 in., with a depth of 10 in.

1618. *Proposed by Fred Marer, Los Angeles.*

Prove $\cot x/2^n - \cot x > n$, for $n > 0$ and $0 < x < \pi$.

1619. *Proposed by John P. Hoyt, Cornwall, N. Y.*

The equilateral triangle ABC is inscribed in a circle. Find a point, P, in arc AB such that chord PB is a mean proportional between chords PH and PC.

1620. *Proposed by O. T. Snodgrass, Yankton, S. Dakota.*

In a given circle inscribe an angle of 30 degrees whose sides shall pass through two fixed points within the circle.

1621. *Proposed by David X. Gordon, Brooklyn, N. Y.*

Prove geometrically that, if $a^2+b^2=1$ and $x^2+y^2=1$, a, b, x, y, positive and real. $ax+by<1$.

SCIENCE QUESTIONS

June, 1939

Conducted by Franklin T. Jones

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send in your "Do You Know the Answer?" Questions.

Please send copies of tests and examinations to Franklin T. Jones, 10109 Wilbur Avenue, S.E., Cleveland, Ohio.

THINK ABOUT THIS ONE

867. *Proposed by Philip B. Sharpe (GQRA, No. 262), Greenwich High School, Greenwich, N. Y.*

There are more brown rats than white rats in the world, there are more normal-minded people in the world than people having hereditary feeble-mindedness, blondes predominate in Sweden, very few people in the world have webbed fingers or toes, or six fingers. What can be concluded regarding the inheritance of:

(a) Brown color in rats? (2)
(b) Normal-mindedness in man? (2)
(c) Fairness among Swedes? (2)
(d) Webbed fingers or toes in man? (2)
(e) Six fingers in man? (2)

DO YOU KNOW THE ANSWERS?

(*Propose questions with quick answers for this section of* Science Questions. *Classes and teachers are invited to participate.*)

46. Are scientists able to learn the temperature of the water four miles below the surface of the ocean? How?
47. What unit of measure is used for precious stones? How heavy is it?
48. To what does the proverbial saying "scarce as hen's teeth" refer?
49. I tested my speedometer over a "measured mile," holding the pointer at 50 miles per hour. The time elapsed was one minute and thirteen seconds. Was my speedometer reading correctly? Was it fast, or slow, or correct?
50. What kinds of hen lay blue eggs?

ANSWERS—36-40—April, 1939

36. Impressed cycles must be 60 per second for a 60-cycle electric clock. If 58 or any number less than 60 the clock will run slow.
37. A government report says there are 313,900 seeds of red clover in a pound of seed.
38. *Answer by Basil Powell (elected to the GQRA, No. 290), Georgetown, Georgia.*

"The bristles in Dr. West's tooth brushes are made of 'Exton,' the commercial name given one form of the chemical, 'nylon,' which has been developed by the du Pont Company. It possesses beautiful luster and has great tensile strength, elasticity and toughness. Potentially it has a great future in industry." (*Industrial and Engineering Chemistry*, Nov., 1938.)

"Exton" is hexa-methylene-diamino-adipic acid polymer.

39. Can a snake back up? *Packard, GQRA, No. 1, please answer.*
40. Resonance causes many "rattles." If loose, so it can vibrate, the china cabinet would rattle in response to some of the various vibrations from the radio.

THE BURSTING CASK

853. *Question by John M. Michener (GQRA, No. 117).*

"What's wrong with the illustration of the cask bursting under a head of 10 feet of water?"

Answer: C. O. Pauley (GQRA, No. 266) showed in his answer to 851 (April, 1939) that the "seams of the cask began to give way" under a head of about 15 feet of water.

GRAPHIC TEST IN CHEMICAL REACTIONS

861. *Proposed by K. F. Keirstead (GQRA, No. 270), St. Andrews High School, New Brunswick, Canada.*

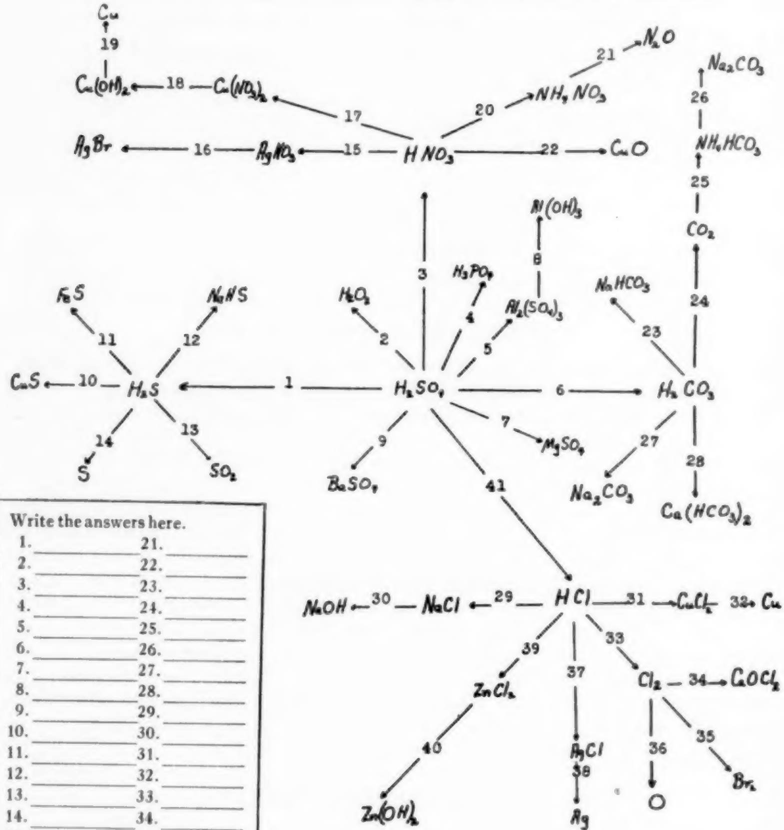
Directions: Each number in the table of the lower left-hand corner corresponds to an element or compound that will combine with a given compound to give a required product.

Look at #41. Say to yourself: "What material will combine with H_2SO_4 to produce HCl?" One answer is NaCl. This answer is written opposite #41. Note that any other chloride may be used.

Opposite each number write the element or compound that will combine with the given compound to give the required product.

Test in Chemical Reactions

K. F. Keirstead, St. Andrews High School, N. B., Canada.



Write the answers here.

1.	21.
2.	22.
3.	23.
4.	24.
5.	25.
6.	26.
7.	27.
8.	28.
9.	29.
10.	30.
11.	31.
12.	32.
13.	33.
14.	34.
15.	35.
16.	36.
17.	37.
18.	38.
19.	39.
20.	40.
	41. NaCl

PATH OF A BULLET

855. *Question and answer by Carter Frank (GQRA, No. 267), Riverside High School, Buffalo, N. Y.*

Will a bullet fired from a gun barrel that is perfectly level rise above the muzzle of the gun as it appears to do in pictures of bullet flight trajectories?

Answer: No it does not. During the time the bullet is traveling up the barrel, the barrel does rise a little higher than before the sight was taken. This rise of the muzzle is due to recoil, a recoil must cause the barrel to rise if it does anything to it, since the center of resistance is below the level of the bore.

GQRA—Picnic—Summer 1939

At *Pen' Bryn*, RFD 1, Box 241, *Geneva, Ohio.*

On State Route 531, 1,000 feet east of Geneva Township Park.

Stated day—*July 30, 1939*—Sunday.

Stop any day on your way east or west—only four miles off U. S. Route 20. The *Editor*, or his daughter, Miss Helen H. Jones, will be glad to see you.

BOOKS AND PAMPHLETS RECEIVED

The Phylum Chordata, by H. H. Newman, Professor of Zoology in the University of Chicago. A Revision of *Vertebrate Zoology*. Cloth. Pages xiv+477. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.60.

College Algebra, by H. L. Rietz, University of Iowa, and A. R. Crathorne, University of Illinois. Fourth Edition. Cloth. Pages xviii+298. 13.5×21.5 cm. 1939. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.85.

Mathematics in Action, by Walter W. Hart, formerly Associate Professor of Mathematics, School of Education, University of Wisconsin, and Lora D. Jahn, Adviser Junior High School Mathematics Committee, Vice-Principal Junior High School Number One, Trenton, New Jersey. Cloth. Pages viii+344. 13×20 cm. 1939. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price 88 cents.

The Concepts of the Calculus, by Carl B. Boyer. Cloth. Pages viii+346. 15×23 cm. 1939. Columbia University Press, 2960 Broadway, New York, N. Y. Price $3.75.

Crystalline Enzymes, by John H. Northrop, Member of the Rockefeller Institute for Medical Research. Cloth. Pages xviii+176. 1939. Columbia University Press, 2960 Broadway, New York, N. Y. Price $3.00.

Algebra and Its Uses, Book One and Book Two, by Nathan Siberstein, Chairman of the Mathematics Department, James Monroe High School, New York City; Marquis J. Newell, Mathematics Department, Evanston Township High School, Evanston, Illinois; and George A. Harper, Headmaster, Southern Arizona School for Boys, Tucson, Arizona. Cloth. 12.5×20.5 cm. 1938. Book One, revised edition. Pages 432+xvi. Book Two, pages 432+xxiv. Row, Peterson and Company, 1911 Ridge Avenue, Evanston, Ill. Price $1.24 each.

Teaching the New Arithmetic, by Guy M. Wilson, Professor of Education, Boston University, Boston, Massachusetts; Mildred B. Stone, Instructor in Mathematics, State Teachers College, Salem, Massachusetts; and

Charles O. Dalrymple, Professor of Education, State Teachers College, Worcester, Massachusetts. Cloth. Pages xii+458. 14.5×23 cm. 1939. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $3.00.

Mathematics in Daily Life, by Eugene H. Barker, Polytechnic High School, San Francisco, California, and Frank M. Morgan, Director of Clark School, Hanover, New Hampshire, and formerly Assistant Professor of Mathematics, Dartmouth College. Cloth. Pages vii+432+v. 12.5×19.5 cm. 1939. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.32.

Engineering's Part in the Development of Civilization, by Dugald C. Jackson. Cloth. 114 pages. 13×20 cm. 1939. The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y. Price $1.55.

The Rockefeller Foundation, A Review for 1938, by Raymond B. Fosdick, President of the Foundation. Paper. 72 pages. 15.5×23 cm. The Rockefeller Foundation, 49 West 49th Street, New York, N. Y.

Greek Mathematics and Astronomy, by Sir Thomas Little Heath. Reprinted from *Scripta Mathematica*, Vol. 5, No. 4. October, 1938. 18 pages. 16.5×24.5 cm. Price 25 cents.

A Mathematical Prodigy History and Legend, by Cassius J. Keyser. Reprinted from *Scripta Mathematica*, Vol. V, No. 2. April, 1938. 12 pages. 16.5×24.5 cm. Price 20 cents.

Homemaking Cottages, Their Use in Homemaking Education. Bulletin 322. Written and compiled by the Federal Writers' Project, Works Progress Administration Commonwealth of Pennsylvania. 42 pages. 14.5×23 cm. 1939. Department of Public Instruction, Commonwealth of Pennsylvania, Harrisburg, Pa.

The Language of Modern Education. Bulletin 17. Lester K. Ade, Superintendent of Public Instruction. 46 pages. 15×23 cm. 1939. Department of Public Instruction, Harrisburg, Pa.

Developing Facility in English Composition. Bulletin 281. Lester K. Ade, Superintendent of Public Instruction. 16 pages. 15×23 cm. 1939. Department of Instruction, Harrisburg, Pa.

Vocational Agriculture in Pennsylvania. Bulletin 250. Lester K. Ade, Superintendent of Public Instruction. 30 pages. 15×23 cm. 1939. Department of Instruction, Harrisburg, Pa.

Pertinent Questions and Answers Pertaining to Professional Education, Examination, and Licensure. Bulletin 600. Lester K. Ade, Superintendent of Public Instruction. 49 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Vocational Industrial Evening Classes. Bulletin 330. Lester K. Ade, Superintendent of Public Instruction. 47 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Instruction, Harrisburg, Pa.

In-Service Education of Teachers. Bulletin 155. Lester K. Ade, Superintendent of Public Instruction. 23 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Instruction, Harrisburg, Pa.

Teacher Placement. Bulletin 152. Lester K. Ade, Superintendent. 31 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Instruction, Harrisburg, Pa.

Nucletronics, The Fundamentals of Force and Matter, by Hjalmar Herrstrom, Physicist. Paper. 23 pages. 15×23 cm. 1939. H. Q. Herrstrom New Ulm, Minn. Price $1.00.

Creeping, Sprawling, Climbing Plants, prepared and supervised by E. Laurence Palmer, Professor of Rural Education, Cornell University, Ithaca, New York. Paper. 32 pages. 14.5×23 cm. Cornell Rural School Leaflet. Volume 32, No. 4. March, 1939.

Consumer Science, by Alfred H. Hausrath, Jr., Director of Student Teaching, Iowa State College, Ames, Iowa, and John H. Harms, Head of the Science Department, Ames High School, and Supervisor of Student Teaching in Science, Iowa State College, Ames, Iowa. Cloth. Pages xii+692. 15×23.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.40.

Conservation in the United States, by A. F. Gustafson, Professor of Soil Technology; H. Ries, Professor of Geology; C. H. Guise, Formerly Professor of Forest Management; and W. J. Hamilton, Jr., Assistant Professor of Zoology, all of Cornell University, Ithaca, New York. Cloth. Pages xi+445. 16.5×24 cm. 1939. Comstock Publishing Company, Inc., 124 Roberts Place, Ithaca, N. Y. Price $3.00.

Synthetic Projective Geometry, by R. G. Sanger, Instructor in Mathematics, University of Chicago. Cloth. Pages ix+175. 14×20.5 cm. 1939. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.00.

Birds, by Gayle Pickwell, Professor of Zoology at San José State College, San José, California. Cloth. Pages xvi+252. 22.5×29 cm. 1939. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.50.

The Mechanism of Thought, Imagery, and Hallucination, by Joshua Rosett, Professor of Neurology in Columbia University, Scientific Director, Brain Research Foundation, Inc., New York, N. Y. Cloth. Pages x+289. 17×25.5 cm. 1939. Columbia University Press, 2960 Broadway, New York, N. Y. Price $3.00.

Between Pacific Tides, by Edward F. Ricketts and Jack Calvin. Cloth. Pages xxii+320. 15×23 cm. 1939. Stanford University Press, Stanford University, Calif. Price $6.00.

Conquests of Science, edited by Ray Compton, Principal, Thomas A. Edison Junior High School, Los Angeles, California, and Charles H. Nettels, Principal, Canoga Park High School, Los Angeles, California. Cloth. Pages vi+378. 13.5×19.5 cm. 1939. Harcourt, Brace and Company, New York, N. Y. Price $1.20.

BOOK REVIEWS

Advanced Analytic Geometry, by Alan D. Campbell, Professor of Mathematics, Syracuse University. Cloth. Pages x+310. 14×21.5 cm. 1938. John Wiley and Sons, 440 Fourth Avenue, New York, N. Y. Price $4.00.

"The purpose of this book is to introduce the student to the analytic side of projective geometry. It leads him from concepts and methods of elementary analytic geometry to the ideas of cross-ratio, triangle of reference, general projective transformation, etc. Being introductory in nature, this book does not aim to give complete discussions of transformation groups and subgroups, of invariants, or of other advanced topics."

The book is divided into two parts. Part I is an introduction to affine plane analytic geometry. Part II is an introduction to general plane analytic projective geometry.

The book is flexible in that it is possible by selecting the first eight chapters to arrange a semester course to follow elementary analytic geometry. An advanced senior college semester course can be arranged by selecting certain sections from Part I for hasty reading and then proceeding to Part II.

J. M. Kinney

Theory of Equations, by Joseph Miller Thomas, Professor of Mathematics, Duke University, Durham, North Carolina. Cloth. Pages x+211. 13.5×20.5 cm. 1938. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.00.

In the preface the author says that he has been guided by a two-field purpose: to make the treatment agree in spirit and terminology with what is called modern algebra and to lead up to the Galois theory.

He justifies the publication of another book on the theory of equations on the ground that the form of statement and the proofs of some of the theorems are new. The following are cited as examples: the classification of permutations into even and odd without the use of the alternating function; the discussion of linear systems; the statement of Budan's and Sturm's theorems so as to include the upper end point of the segment considered; the proof of Budan's theorem; the elementary discussion of a limit to the error in Horner's method; the discussion of the resultant; and the solution of simultaneous non-linear systems. There are twelve chapters with headings as follows: Introduction; Permutations; Determinants; Systems of Linear Equations; Polynomials in a Single Indeterminate; Graphical Methods; Roots of Unity; Single Equation in a Single Unknown; Symmetric Functions; Constructibility; Resultants and Discriminants; Simultaneous Systems.

From the standpoint of teachability the book seems to rank high.

J. M. KINNEY

Medieval Number Symbolism, Vincent Foster Hopper, Assistant Professor of Literature, New York University School of Commerce, Accounts, and Finance. Cloth. Pp. xii+241. 14×21.5 cm. 1938. Columbia University Press, 2960 Broadway, New York, N. Y. Price $2.90.

The author in his preface states that "It is the purpose of this study to reveal how deeply rooted in medieval thought was the consciousness of numbers, not as mathematical tools, nor yet as counters in a game, but as fundamental realities, alive with memories and eloquent with meaning."

In order to make understandable the medieval number philosophy which may appear when isolated as nonsense the subject is treated relative to its origins in the number system of primitive man, in ancient Babylonian astrology of which much is repeated in the Bible, and in the number theory of the Pythagoreans. There are seven chapters as follows: I. Elementary Number Symbolism; II. The Astrological Numbers; III. The Pythagorean Number Theory; IV. The Gnostics; V. The Early Christian Writers; VI. Medieval Number Philosophy; VII. The Beauty of Order—Dante. There is an appendix on number symbols of northern paganism and a bibliography covering twenty pages.

J. M. KINNEY

Gems and Gem Materials, by Edward Henry Kraus, Ph.D., Sc.D., Professor of Crystallography and Mineralogy, and Dean of the College of Literature, Science and the Arts, University of Michigan, and Chester Baker Slawson, Ph.D., Assistant Professor of Mineralogy, University of Michigan. Third edition. Cloth. Pp. xiii+287. 3×16×23 cm. The McGraw-Hill Book Co., New York, N. Y. 1939. Price $3.50.

Students and lovers of gems and gem-minerals will be glad to see this new edition of the very fine work first published under the authorship of Professor Kraus and the late Edw. F. Holden and then, in its second edition by Professor Kraus. As was acknowledged in the preface of the second edition, Professor Slawson was of much assistance in preparing

that revision and he has now brought still further aid to the senior author as co-worker with him in the new edition.

The book has been entirely reset, somewhat enlarged, thoroughly revised and brought up to date and 65 new illustrations have been added. Four excellent colored plates have been inserted. A brief new chapter deals with the precious metals and their common alloys as used in jewelry.

One of the outstanding merits of the book is its unusually good treatment of the subject of synthetic stones. As a result of first-hand experience in personally visiting a number of the more important European manufacturers of synthetic stones the senior author put himself in a position to speak with authority about their manufacture and obtained excellent illustrations both of the appliances in use and of the product.

For those who may be unacquainted with the general characteristics of the book, we may add that it treats in a comprehensive manner of the forms, properties, formation, occurrence and characteristics of gems and gem materials, describing almost all gems of any commercial importance. There are sections on gem cutting and polishing and on imitation stones and altered stones. A generous series of tables and a systematic classification of all the gems according to their color, luster, hardness, specific gravity, crystallization, optical properties and localities, completes the book. All of the host of gem mineral collectors and all students of mineralogy should avail themselves of this new edition.

FRANK B. WADE

An Introduction to Business Statistics, by John R. Stockton, Associate Professor of Business Statistics, The University of Texas. Cloth. Pages v+378. D. C. Heath and Company, Boston, Mass. 1938. Price $3.00.

This book covers the topics usually considered in a first course in business statistics, but in treating each topic the author includes a discussion of its significance for the business man. Particular emphasis is given to the way in which different statistical methods are actually used in business, and for this purpose a great mass of authentic statistical data is employed. Each topic is very carefully and comprehensively treated and the student should experience but little difficulty in comprehending the material as it is presented.

In one of the appendices the book lists forty-seven statistical problems designed to give students practice in computing different statistical measures, and experience in using data and analyses in forming business judgments. The problems are based on real situations and real data which the students analyze before arriving at decisions.

In the other appendices are listed tables of logarithms, squares, square roots and reciprocals, a description of adding and calculating machines, statistical formulas, a glossary of symbols, forcing percentages to total one hundred and significant figures.

The book should find favor with both the student and teacher of business statistics.

CHARLES A. STONE

Laboratory Manual and Problems for Elements of Statistical Method, by Albert E. Waugh, Professor of Economics, Connecticut State College. Cloth. Pages x+171. McGraw-Hill Book Company, New York. 1938. Price $1.50.

The problems in this manual are obviously designed for the usual course in elementary statistics, and can be used with any text suitable to the course. The manual follows the author's "Elements of Statistical Method," and references in the manual apply to that book. Any course in statistics,

general or specific, will find appropriate illustrative material in the manual.

According to the author the material offered is taken from actual problems, and the cases have been selected with the aim of minimizing the drudgery of arithmetical computation without oversimplifying the problems beyond all semblance of reality.

Many types of problems are included for the purpose of satisfying individual interests and giving the student an appreciation of the wide range of problems to which statistical materials are applicable.

The book lists a great number of statistical formulae and contains many tables that save time for the student from the standpoint of computation. The uses of the tables are explained by means of short illustrative examples given in sections immediately preceding them.

This book should prove useful to any student enrolled in an elementary course in statistics and should also find favor with teachers of such courses.

CHARLES A. STONE

A Course in General Mathematics, by Clinton Harvey Currier, Associate Professor of Mathematics, Brown University, Emery Earnest Watson, Professor of Mathematics, Iowa State Teachers College, and James Sutherland Frame, Assistant Professor of Mathematics, Brown University. Cloth. Pp. ix+382. 15×22 cm. Revised edition, 1939. The Macmillan Company, New York, N. Y. Price $3.00.

This is a text for first year college mathematics. It includes the elements of College Algebra, Trigonometry, Plane and Solid Analytic Geometry, and the beginnings of Differential and Integral Calculus. The treatment of Trigonometry is reasonably complete, and perhaps there is sufficient material on Plane Analytic Geometry to meet the needs of students who will not take more mathematics. Necessarily, in a volume of this size, the treatment of all topics of the various subjects could not be extensive. The Algebra, Solid Analytics and Calculus are very briefly handled. The materials of the various subjects are well integrated. The explanations are concise and clear, and there are many worked examples. There is an abundance of problem material and there are many historical notes. Answers are given for the problems. Brief tables are printed in the book. The book would supply abundant material for a year of mathematics.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Enriched Teaching of Mathematics in the Junior and Senior High School, by Maxie Nave Woodring, Professor of Education, Teachers College, Columbia University, and Vera Sanford, Head of the Department of Mathematics, State Normal College, Oneonta, New York. Cloth. Pp. ix+133. 1938. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.75.

Here is a valuable book for any teacher of mathematics, department head, supervisor or college instructor who is training teachers of mathematics. It is a general catalog listing supplementary materials such as work books, testing materials, pictures, slides, texts, practical applications, materials for clubs and special reports, periodicals and recreational materials. Much of the material listed is free. The addresses and prices of manufacturers are given. Brief descriptions of the materials are included. The former edition has been carefully revised and brought down to date. If you have this book, you will probably have at hand a ready answer to every question, "Where can I get it?"

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Coordinate Solid Geometry, by Robert J. T. Bell, Professor of Mathematics in the University of Otago, Dunedin, N. Z. Cloth. Pp. xiii+217. 1938. Macmillan and Company, Limited, St. Martin's Street, London, England, and The Macmillan Company, New York.

This volume is Chapters I to XI of the author's "Elementary Treatise on Coordinate Geometry of Three Dimensions." It presupposes a good knowledge of Plane Analytic Geometry, Algebra and Calculus. It is suitable for graduate students or for advanced undergraduates. The work is scholarly and complete and will meet the needs of those interested in pure or applied mathematics. There are numerous lists of problems.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Algebra, An Interesting Language, by Ernst R. Breslich, Department of Education, The University of Chicago. vii+77 pages. 1939. The Orthovis Company, Chicago, Ill.

This book is well written to supply the beginner's first contacts with algebra. It will enable him in the briefest possible time to learn "what it is all about." In a few pages well written and interestingly illustrated with many good pictures, the author has given an introduction to the subject in a very attractive manner. It might well be studied entire before any text is placed in the hands of the beginner. It is also a very useful book for the teacher who wishes to find interesting ways to introduce various topics so that they seem alive to the pupil.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Animals Without Backbones, by Ralph Buchsbaum, Department of Zoology, The University of Chicago. Cloth. Pages ix+371. 16.5×23 cm. 1938. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $3.75.

In the author's words, "This book is an attempt to present the main groups of invertebrate animals in simple nontechnical language. Each group is used to illustrate some principle of biology or some level of the evolution of animals from simple to complex forms."

All of the phyla of invertebrates are described and the space is apportioned in accordance with the importance of the respective groups. Fourteen of the twenty-eight chapters are indicated as basic or "indispensable chapters" to be read by the students of the "Introductory General Course in Biology" at the University of Chicago. The remaining chapters are intended as optional reading for the invertebrate section of a general course or to be used in conjunction with the indispensable chapters as a textbook for a college course in invertebrate zoology.

The book contains more than 550 illustrations. These are of two types: (a) drawings, (b) gravure photographs. The drawings are all original or modified; they are the product of the author's sister, an artist with unusual ability in clarifying structural relationships. The photographs, constituting the finest collection to appear in an American textbook on zoology, are designed to "supply the elements of specific form and texture which are missing from the diagrammatic stylized drawings. They are intended as a sort of laboratory exhibit and vicarious field experience."

From an artistic point of view the photography and the reproduction of the photographs as gravures are superb. With their printed legends they fully occupy 128 pages. They are grouped at the end of the various chapters and are not paged in with the text; the book therefore is thicker by 128 pages than indicated in the published description.

The clear and simple style, the reduction of the technical terminology,

and the beautiful illustrations make this a valuable reference work for the high school student. It should of course find a place in every college library and laboratory of invertebrate zoology.

The author and artist in particular as well as the publishers, photographers, and others who have contributed to the production of this attractive volume deserve our warmest congratulations.

EDWARD C. COLIN, *Chicago Teachers College*

College Biology, by Walter H. Wellhouse, Professor of Biology and George O. Hendrickson, Assistant Professor of Zoology, Iowa State College. Cloth. Pages viii+391. 14×21.5 cm. Second edition, 1939. F. S. Crofts & Company, New York. Price $3.00.

This book is essentially a reprint of the first edition published in 1936 (reviewed June, 1937, SCHOOL SCIENCE AND MATHEMATICS) plus a short new chapter on Conservation. A few substitutions of improved figures have been made, with a number of corrections and changes in the text.

In the new edition we still find the statement that mutations, such as albinism and spotting in mammals, are due to the absence or elimination of genes. Several lines of evidence including the study of the salivary gland chromosomes in flies and the fact of reverse mutations indicate that ordinary mutations are not losses of genes but are rather changes therein.

To many biologists the most striking peculiarity of this text—old edition as well as new—is its discussion of the evidences and theories of organic evolution without mentioning the word *evolution*. This is mute evidence of the power of a single word and of the prejudice against it which evidently still exists in the minds of certain sections of our people. Although the discussion of evolution is weakened by its failure to deal frankly with certain aspects of the problem, the treatment, so far as it goes, is sound and valuable. It is to be hoped that when the readers of the book discover that they have been studying evolution they will not feel that they have been tricked but will be stimulated to go further with it. A happy day for science and civilization will arrive when the last vestige of this ancient prejudice against evolution is finally eliminated from human consciousness.

EDWARD C. COLIN, *Chicago Teachers College*

Introduction to College Mathematics, M. A. Hill, Jr., University of North Carolina, and J. Burton Linker, University of North Carolina. Cloth. xiv+374+94. 16×24 cm. 1938. Henry Holt and Company, New York. Price $2.40.

This book is written with a view of providing for two classes of students in one course—those that desire the subject as a sound basis for future work; and those that pursue non-scientific studies but wish to learn in a year's time something of the nature and scope of the broad field of mathematics.

Part I is written so as to present the subject of algebra and trigonometry in such a way that the processes learned in the algebraic solutions are at once used in problems involving trigonometric solutions. The general trigonometric ratios are introduced early in the course and are thenceforth used with the algebra in the study of graphs, factoring, fractions, linear equations, quadratic equations, equations of higher degree, functions of multiple angles, oblique triangles, and complex numbers.

Part II (119 pages) includes the basic principles of analytic geometry and the calculus. The chapter titles of this section are the straight line, the circle, the conics, polar and parametric forms, differentiation (35 pages), and integration (12 pages).

There are twenty pages of answers to the odd-numbered problems. The

list of tables includes logarithms of numbers and of trigonometric functions, natural trigonometric functions, and conversion tables of degrees, minutes, and seconds to radians and vice versa.

JOSEPH J. URBANCEK, *Woodrow Wilson Junior College, Chicago*

Conquests of Science. The Discovery Series by Ray Compton, Principal, Thomas Edison Junior High School, and Charles H. Nettels, Principal, Canoga Park High School. Cloth. Pages 378. Harcourt, Brace and Company, New York, 1939.

This book is made up of reprints of chapters selected from the best of literature and covering a wide range of science fields. These selections are very satisfying to the reader because while brief they are complete and are not like the skeletons of articles which are so frequently offered to busy people and which trick us into thinking that the pre-digested material could give us the satisfaction that we do get from the original.

The authors tell us that the book has been prepared in the hope that it will make it possible for many to read of the fascinating world of science, and it is true that for many of us our scientific conquests will indeed be limited to the vicarious enjoyment of the deeds of others. In the section devoted to the Animal Kingdom, one experiences with Ivan Sanderson the horrible sensation of suffocation in the bat's cavern, watches with William Beebe the baby hoatzin meeting danger unafraid and learns to appreciate "the unselfish struggle with intelligence matched against ignorance" which is the story of science. The story of the Wright Brothers, of Burbank and of Madame Curie, the explorations of Roy Chapman Andrews in the Gobi Desert, with chapters from the experiences of Dr. Victor Heiser, are a few of the other adventures that are found between the covers of this book.

There are many fine photographs illustrating the several sections of the book and at the end, besides a glossary of scientific terms, there is an interesting chapter on scientific hobbies. The fine bibliographies throughout the book add to its value and really make it a nucleus for a complete library. Children in the junior and senior high schools will enjoy this book as much as adults will.

PAUL F. DEVINE, *Los Angeles, Calif.*

Appraising Observable Behavior of Children in Science, by Joe Young West, Teachers College, Columbia University, Contributions to Education, No. 728. Cloth. 118 pages. 14.5×23 cm. 1937. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.60.

Assuming that a modern program of science teaching will modify the behavior of the children engaged in such study, the author has set up a technique for controlling the observation of defined units of behavior of individuals or groups. Observation was carried on in an informal and a formal type of school. In both cases the science objectives of the school were set up in terms of pupil responses or units of behavior. These responses were then made into a code that could readily be used during observation. By the application of this code during consecutive daily observations of a group for limited periods of time the observer was able to determine the extent to which the science objectives listed were being attained.

The controlled observation technique has been highly refined in this study, eliminating the subjective element almost entirely. The refinement of the technique and the thoroughness of its application is the outstanding contribution of the book. Those interested in finding techniques for appraising outcomes in education will find this study very helpful. This technique makes possible an objective record of classroom behavior.

The advantages of the technique as suggested by the author are: (1) the use of this instrument does not interfere with the normal activity in the classroom; (2) data obtained lend themselves to statistical treatment; (3) the technique may be adapted to the study of different kinds of behavior in other school situations; (4) behavior samples taken for short intervals upon successive days tend to cancel out disturbing elements.

A disadvantage of the technique is that securing enough observations is time consuming.

From the observations made it was found that the larger objectives of modern science teaching can be used for guidance by teachers of science in elementary schools and that children recognize important elements of the scientific method.

ARTHUR WITT BLAIR, *National College of Education, Evanston, Illinois*

Snakes Alive and How They Live, by Clifford H. Pope. Cloth. Pages xii+238. 14.5×21.5 cm. 1937. The Viking Press, 18 East 48th Street, New York, N. Y. Price $2.50.

The title, "Snakes Alive," attracts the attention; the comprehensive content, excellent photographs and literary style hold the attention. I have found that high school pupils and laymen as well as university students and teachers consider the book very interesting and worthwhile.

Mr. Pope begins with a story of his early interest in snakes and of his adventures as a snake collector in China. He continues with a thorough discussion of the following topics: usefulness of snakes, size, age and growth, senses and intelligence, feeding habits, reproduction, speed and methods of locomotion, defense tactics, enemies, different habitats, distribution, hibernation, popular beliefs about snakes, snakes as medicine, venoms and their uses, treatment of snake bites, snake hunting and what to expect of snakes as pets. A simplified key for identifying snakes takes up the last forty pages of the book. This key is designed to enable the pupil to learn the distribution or range as well as to identify any snake in the United States. It is illustrated with many excellent diagrams.

The contents of this book are easily understood by the novice. This readability was achieved without omitting important information or oversimplification. The author completely avoids giving the impression of writing down for the less-informed reader. The material is illustrated by a large number of exceptionally fine photographs. Each plate depicts a complete story in itself.

This book should accomplish a great deal in furthering a general interest in snakes and in developing a true understanding of their value. It merits a place in school and public libraries as well as in general science, biology and zoology laboratories.

LYLE F. STEWART

Experiences in Physics, by Lester R. Williard assisted by Charles S. Winter, both of Thomas Jefferson High School, Elizabeth, New Jersey. Cloth, 17.5×24 cm. Pages x+662. 1939. Ginn and Company, New York. Price $1.92.

Experiences in Physics is the result of the authors' efforts to devise a course in physical science which will meet the needs of the high school pupil of today, who usually is not interested in mathematics and is bored by too much theory. It is unique in that it clearly recognizes the fundamental principle that pupils learn science best by first-hand experience with it, rather than by reading about it. The book presents information

as an explanation or an elaboration of some experience, rather than an isolated fact worth knowing and, therefore, should broaden the student's background without killing his interest in the course.

The organization of material is quite orthodox, as it divides the course into six large units, which are further divided into chapters of closely related subject matter. There is a large unit built around each of the following titles: Matter, Forces, Heat, Sound, Light, and Electricity. Because the course is built around experiences or activities which are carried on by the student, a separate laboratory manual is not necessary, adequate laboratory exercises and supplementary demonstrations being an integral part of the text.

Purely mathematical operations have been reduced to a minimum, but there is a wealth of thought questions which will tax the ingenuity of even the best students.

The book is profusely illustrated, and the typographical set up is such that it makes for very easy reading. This text should considerably reduce the problem of the instructor who wishes to make physical science functional in classes of widely varying ability.

W. A. PORTER

MOTION PICTURE REVIEWS

Man Against Microbe. The Metropolitan Life Insurance Co., Welfare Division, 1 Madison Ave., New York City. Also from YMCA Motion Picture Bureau, 347 Madison Ave., New York City. 1 reel. 16 and 35 mm., silent and 35 mm. sound. (Silent film seen by reviewing group). Loaned without charge.

I. The Story of the Film.

Beginning with plague victims of 300 years ago, this film traces the steps by which man has gained his present mastery over disease. The treatment is episodic and presents the historic figures in the struggle: Leeuwenhoek and his simple microscope; Plencig, who first contended that disease is caused by germs; Pasteur, who actually showed that germs may cause disease and that they may be destroyed by heat; Lister, with his demonstration that germs can be destroyed by chemical action; Pasteur, again, with his vaccine treatment; Robert Koch; von Behring and his use of antitoxin on human patients. Final scenes show modern immunization and point the the way for future work.

II. Criticism of the Film as a Teaching Aid.

The material is well organized on the whole and so clearly developed that the film can be used for motivation purposes, for summary, or as a source of information, in connection with work in science at a number of levels. A commercial film, "Man Against Microbe" is nevertheless free of advertising and is of an acceptable educational quality. Two minor faults were noticed: (1) the titling tends to be verbose, and (2) there is a confusion of protozoa with germs at one point. Perhaps the most severe criticism is that the film somehow fails to create a feeling of excitement and adventure. Perhaps this is due to the episodic treatment noted above, or to the fact (a concomitant of the same situation) that we are not allowed really to savor any of the happenings to a point where deeper emotions may be sitrred.

III. Technical Qualities of the Film.

The photography and other technical features of the film seem generally

adequate. In one or two of the scenes, the camera seems to have been placed at a point too far away, i.e., the figures are too small.

IV. Rating.

1. Age level: Of value at all grade levels
2. Quality of photography: Generally satisfactory
3. Selection of scenes: Good, except that sequences are often too short
4. Quality of Captions: Satisfactory in most respects, except in excess length.

The Formation of Volcanoes and Geysers. Society for Visual Education, Inc., 327 South LaSalle St., Chicago, Ill. 16 mm. silent, 1 reel. Sale $20.

I. The Story of the Film.

The film attempts to explain the process of vulcanism by means of blackboard drawings. The layers of rock are first diagrammed and the molten rock below the surface is forced upward through these layers. Successive eruptions create a volcanic mountain. Cracks in the sides of the mountain develop and through these molten rock also flows producing smaller craters. The formation of geysers is presented by the same technique. An opening from the surface to heated layers of rock is shown and, in a way, that is not clearly presented, water fills the opening and is erupted. Brief views of a volcanoe and of an erupting geyser (probably Old Faithful) follow immediately after the two blackboard episodes.

II. Criticism of the Film as a Teaching Aid.

Either as a device for teaching subject-matter or of stimulating interest, the film has little to recommend. A skillful teacher could present all that the film does, and with probably greater effectiveness. The action of the film is slow and fails to hold interest.

III. Technical Qualities of the Film.

Here is an example of a film which, while it deals with a subject which is admirably adapted to treatment in motion pictures, is almost valueless because of the outmoded technique employed. Why, oh why, should so many weary feet of film be devoted to a man making a drawing on a blackboard? The whole subject cries for the wise use of actual scenes and animated drawings, possibly with the use of sound. There are a number of minor errors in the film (e.g., when a lava-cone is labeled a "cinder-cone") and the actual scenes of what purports to be a volcanoe are wasted since they are not identified in any way and rather resemble views of a large oil fire.

IV. Rating.

1. Age level: Of little use at any level
2. Quality of photography: Fair
3. Selection of Scenes: Very poor.

Reviewing committee
Henry Alderfer
N. Eldridge Bingham.
Hubert M. Evans
F. T. Howard
Alton I. Lockhard
Ross Wyler
H. Emmett Brown, *Chairman*

SOME EASY PROJECTS IN CHEMISTRY

No. VII. Manufacture of Guncotton

Francis Ingley, *Senior High School, Orlando, Florida*

Guncotton is popularly thought to be both difficult and dangerous to make even on a small scale. However, if a few simple precautions are observed and care is used, it is in reality quite a simple matter.

To begin with, three materials are necessary—concentrated sulfuric acid (specific gravity 1.84), sodium nitrate and ordinary absorbent cotton. In the procedure first pour about 20 c.c. of sulfuric acid and about 20 grams of powdered sodium nitrate into a glass retort. A flask may also be used although with less satisfactory results. Fasten the stoppered retort securely to a ring stand and arrange for condensing the acid product. Then begin to heat the retort slowly at first from the side, taking care to keep the hands from under the retort. After the reaction has ceased, you will find a yellow-colored acid in the condensing receptacle. The simplified equation is: $H_2SO_4+2NaNO_3\rightarrow 2HNO_3+Na_2SO_4$. This is fuming nitric acid containing oxides of nitrogen and has very great oxidizing ability so handle with care.

After this has cooled, pour twice as much concentrated sulfuric acid as nitric into it and allow the mixture to cool to room temperature in a flask. Then add to the acid mixture as much cotton as can reasonably soak itself in a flask (a small handful) and stir with the bulb of a thermometer for twenty minutes taking care that the temperature remains below 30°C. All of the cotton must be wet with the acid. It is sometimes advisable to keep the flask moving in some cool water to keep the temperature down. When the cotton is soaked for 20 min. pour off the mixed acids, and wash the cotton in this same flask by pouring in water and draining it off about 20 times. Then when the water in which the cotton is washed shows no acid reaction to blue litmus remove, squeeze, and fluff the cotton out and allow it to dry over night on a sheet of newspaper. After it is dry test the cotton by touching a match to a small tuft of it. Pft-t-t!! The cotton disappears!!

This same guncotton is used in preparing celluloid by making a solution in a mixture of alcohol and ether. It is also used in the manufacture of explosives and smokeless powder, as it produces neither smoke nor ash when burned.

STANFORD UNIVERSITY SUMMER CONFERENCE

The seventh annual Summer Conference of the Stanford University School of Education will be held from July 7 to 9, immediately following the meetings of the National Education Association in San Francisco.

"Educational Frontiers" is to be the central theme for discussion at this year's Conference. The topic will be approached from the point of view of, first, the social frontiers which are making new demands upon educational practice and thought; second, the psycho-biological frontiers where research is continually revealing new and educationally significant facts about the human organism; third, significant innovations on educational frontiers consonant with the social and biological frontiers; and fourth, an evaluation of the success of our culture in meeting the needs of youth.

Howard W. Odum of the Institute for Research in Social Science, University of North Carolina, will speak on "Social Frontiers" at the opening session of the Conference, Friday, July 7, at 10 o'clock. On Friday evening, Lewis M. Terman, Professor of Psychology at Stanford University, will speak on "New Evidence on the Nature of the Human Organism." Jesse

H. Newlon, Professor of Education at Teachers College, Columbia University, will discuss "Educational Frontiers" at the general session on Saturday evening; and John W. Studebaker, United States Commissioner of Education, will speak on the subject "Youth Challenges the Culture," at the final session on Sunday morning, July 9.

On Friday afternoon, Saturday morning, and Saturday afternoon there will be a series of forum sessions dealing with many aspects of the central theme and giving opportunity to attendants at the Conference to participate actively and critically in the discussions. Speakers at the forum sessions will be chosen from among educational leaders in all parts of the country.

The Conference is open to the public and will be of particular value to parents, teachers, educational administrators, adult education groups, and social groups which devote a part of their activity to educational work. Stanford University, located thirty-five miles from San Francisco, is easily accessible by train, bus, or automobile to those attending the N.E.A. meetings and the Golden Gate International Exposition. For the duration of the Conference, rooms will be available on the campus to persons who make reservations in advance.

For detailed information on the program, fees, accommodations, etc., write Stanford Education Conference, Stanford University, California.

HALL OF OPTICAL SCIENCE OPENS

On April 20, Bausch & Lomb opened its Hall of Optical Science, in the Museum of Science & Industry, R.C.A. Building, Radio Center, New York City, with distinguished guests from the fields of science, industry, and the government attending a luncheon given by company officials to celebrate the progress of science and to mark some of the particular contributions of optics.

The Hall of Optical Science translates the dry laws of optics into dynamic displays of light, motion, and color, making it easy for the observer to understand many of the principles which guide the lens designer and the optical engineer in the construction of optical instruments.

By merely pushing buttons or turning knobs, visitors may see how different surfaces reflect, refract, or disperse light. Cross sections of such instruments as binoculars and microscopes have been arranged to show the path of light and their mechanical features.

A battery of automatic Balopticons will project a series of Kodachrome slides on a screen, surrounded by a series of niches synchronized to light up to tell the story of the manufacture of spectacle lenses.

Sculptured dioramas and photographic transparencies are used lavishly to dramatize many products. In the binocular display three sailboats appear, one in the distance as seen with the naked eye; a second one as viewed through 6-power binoculars; a third through 10-power binoculars. When a button is pressed the light in the case is dimmed and a transparency discloses a boat under full sail viewed under high magnification.

Ten lectures a day will be given by members of the museum staff on the subject of light, for which a special optical bench equipped with a variety of optical parts has been built for demonstrations.